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POST AUTHORIZATION CHANGE REPORT

MORGANZA TO THE GULF OF MEXICO, LOUISIANA

January 2013

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1 Introduction and Background

The following sections describe the project construction authorization, purpose and scope of the Post Authorization Change (PAC) report, project history, design changes, cost sharing and funding, and related projects.

1.1 Project Authorization

The Water Resources and Development Act of 2007 (WRDA 2007), Public Law 110-114, authorized construction of the Morganza to the Gulf of Mexico, Louisiana hurricane and storm damage reduction project ("Morganza to the Gulf") at a total cost of $886.7 million. Section 1001 of WRDA 2007 states:

> *"(24) MORGANZA TO THE GULF OF MEXICO, LOUISIANA.—*
> *(A) IN GENERAL.—The project for hurricane and storm damage reduction, Morganza to the Gulf of Mexico, Louisiana: Reports of the Chief of Engineers dated August 23, 2002, and July 22, 2003, at a total cost of $886,700,000, with an estimated Federal cost of $576,355,000 and an estimated non-Federal cost of $310,345,000.*
> *(B) OPERATION AND MAINTENANCE.—The operation, maintenance, repair, rehabilitation, and replacement of the Houma Navigation Canal lock complex and the Gulf Intracoastal Waterway floodgate features of the project described in subparagraph (A) that provide for inland waterway transportation shall be a Federal responsibility in accordance with section 102 of the Water Resources Development Act of 1986 (33 U.S.C. 2212)."*

In accordance with the 2002 and 2003 reports of the Chief of Engineers, the Morganza project is authorized as a feature of the Mississippi River and Tributaries (MR&T). To date, Congress has not appropriated any construction funds. Therefore, the project remains in Preconstruction Engineering and Design (PED) phase.

1.2 Purpose and Scope of the PAC Report

Plans in the 2002 Morganza to the Gulf Feasibility Study were developed well before Hurricane Katrina's devastating impact on the New Orleans hurricane levees in August 2005. Changes in hurricane levee design standards and other changes since project authorization caused the Morganza to the Gulf project to exceed the 20 percent cost increase limit specified in WRDA 1986, Section 902.

There are two types of post-authorization reevaluation studies. "General" reevaluation studies are to affirm, reformulate or modify a plan, or portions of a plan, under current planning criteria. "Limited" reevaluation studies should only require modest resources and documentation. If any part of the reevaluation will be complex, or will require substantial resources, or if the recommended plan will change in any way, a general reevaluation is required. General reevaluation studies frequently are similar to feasibility studies in scope and detail. Given the scale of the Morganza to the Gulf project and the significant design changes since authorization, the PAC report resembles a general reevaluation study, but does not include a complete reformulation of the project. The PAC primarily focuses on analysis of two levels of risk reduction (pre- and post-Hurricane Katrina "100-year" designs) along the authorized alignment. The PAC report includes discussions on post-Katrina design criteria, project designs and costs, and economic analysis necessary for plan selection. For a summary of major changes since project authorization, see section 1.5. For example, the term 100-year has been replaced with 1 Percent Annual Exceedance Probability (1% AEP).

The Morganza to the Gulf project authorized for construction in the 2007 WRDA is based on the 2002 Feasibility Report and subsequent 2002 and 2003 Chief of Engineers Reports. Further details are provided in the 2002 documents, which can be accessed online at: www.mvn.usace.army.mil/prj/mtog. The PED phase started two months after publication of the March 2002 Feasibility Report and has continued through the PAC analysis. The PAC report describes all changes to the Morganza project since the 2002 Feasibility Report. These changes have occurred at different points in time over the last 10 years and are based on evolving data sets and methodologies. The following summary highlights sections throughout the PAC report describing project changes and analyses occurring at different periods of time:

- Section 1.3, **Authorized Project Description**, describes the 72-mile authorized levee project as recommended in the 2002 Feasibility Report and the 2002 and 2003 Chief's Reports as authorized by WRDA 2007.
- Section 4, **Initial Reevaluation of the Authorized Plan**, includes a preliminary evaluation of three alternative levee alignment strategies in 2008 (section 4.3), which was a reconnaissance-level analysis for the purpose of determining whether or not there would still be a Federal interest in the project with post-Katrina criteria incorporated and whether a feasibility-level PAC report should be initiated.
- Section 5, **Post Authorization Changes to the Levee Alignment**, describes modifications and extensions to the authorized levee alignment during PED and the PAC analysis. The resulting 98-mile post-authorization levee alignment (see the project map in Attachment 1) is the basis for comparison of two levels of risk reduction in Section 6.
- Section 6, **Evaluation and Comparison of Alternatives**, describes two alternatives that are the primary focus of the feasibility-level PAC analysis. The alternatives follow the same 98-mile levee alignment but at different levels of risk reduction (1% and 3% AEP).
- Section 7, **Description of the Tentatively Selected Plan**, describes the plan that maximizes net benefits, which is the 1% AEP (or 100-yr) alternative.

As the result of post-authorization changes, all project-related benefits and environmental impacts must be updated. A Revised Programmatic Environmental Impact Statement (RPEIS) is being concurrently prepared to document the environmental and socioeconomic impacts. Given the size and complexity of the Morganza to the Gulf project, most of the RPEIS will be at a broad, programmatic level; however, the RPEIS will include in-depth analysis for a few features that have borrow sources identified and are closest to being ready for construction. For those features, the RPEIS provides sufficient detail so that no further environmental clearances would be needed upon signing of the Record of Decision. All other features would require supplemental National Environmental Policy Act (NEPA) documents (i.e. environmental impact statements or environmental assessments) before they can be constructed.

The report will ultimately be reviewed by the Assistant Secretary of the Army (Civil Works) and coordinated with the Office of Management and Budget as appropriate for submission to the Congress.

1.3 Authorized Project Description

The authorized MR&T project, Morganza to the Gulf of Mexico, was intended to function as a 1% AEP hurricane and storm damage reduction system. In addition to hurricane and storm damage reduction, the structural features of the authorized project were designed to provide tidal exchange, environmental benefits, and navigational passage.

1.3.1 Location

The project/study area is about 60 miles southwest of New Orleans, LA (figure 1-1) and includes most of Terrebonne Parish and a portion of Lafourche Parish. The study area extends south to the saline marshes bordering the Gulf of Mexico and encompasses approximately 1,900 square miles.

The Gulf Intracoastal Waterway (GIWW) and the Houma Navigation Channel (HNC) are major waterways in the area. The GIWW passes through Houma in an east-west direction. The HNC extends due south from Houma to the Gulf of Mexico. Bayou Lafourche runs along the northeastern boundary of the project/study area.

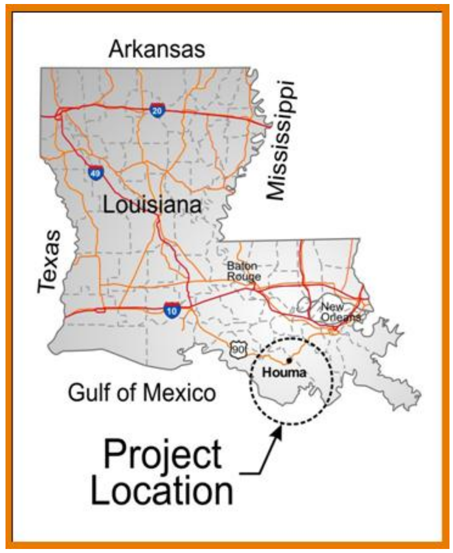

Figure 1-1. General Project Location

The authorized Morganza to the Gulf of Mexico levee alignment primarily follows existing hydrologic barriers, such as natural ridges, roadbeds, and existing local levees. Figure 1-2 shows the authorized Morganza to the Gulf levee alignment. The eastern extent of the authorized levee alignment ties into Larose to Golden Meadow levee south of the GIWW. The western extent of the authorized alignment ties into the Bayou Black ridge north of the GIWW.

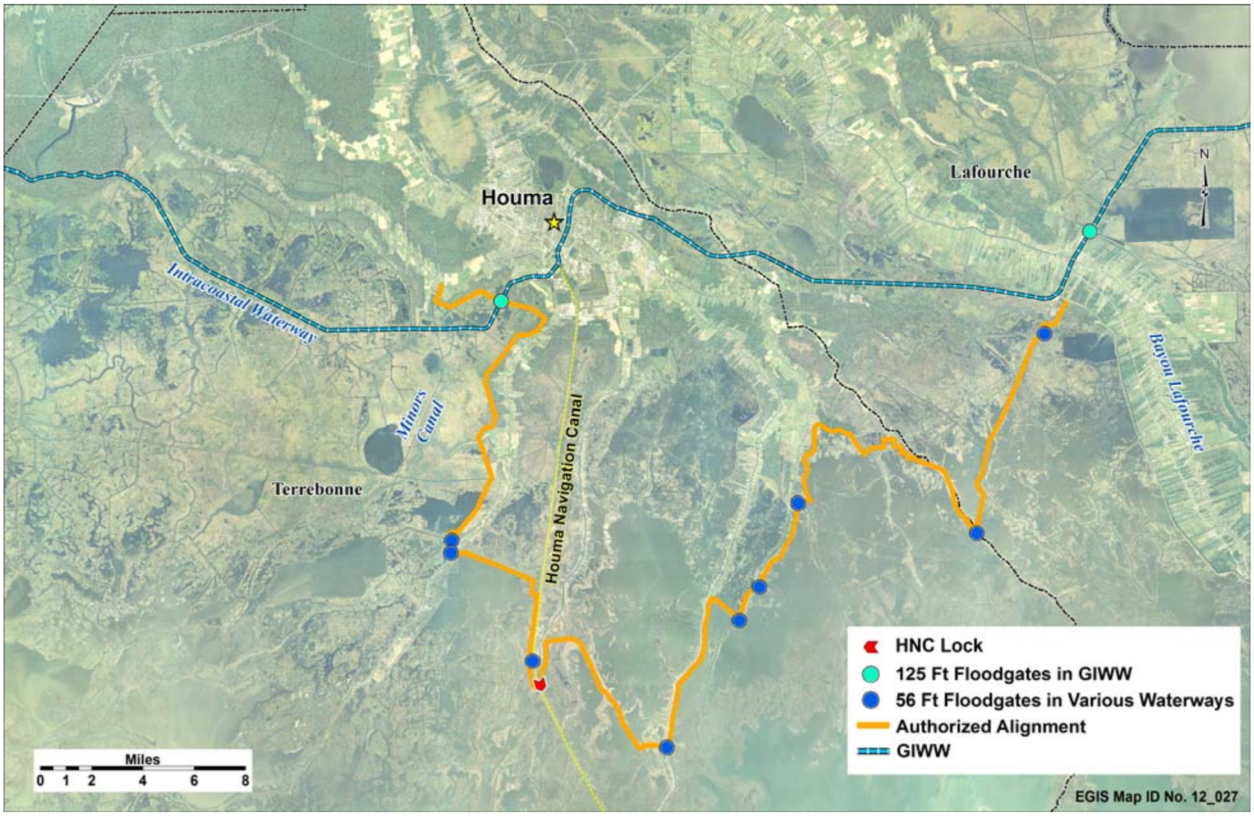

Figure 1-2. Authorized Project Map

1.3.2 Features

The August 2002 Chief's Report recommended a plan to reduce hurricane and storm damages by providing a 1% AEP (referred to as 100-year in the Chief's Report) level of risk reduction including the following features:

> *"…raising or constructing 72 miles of levees to elevations varying from +15.0 feet National Geodetic Vertical Datum (NGVD) to +9.0 feet NGVD. The plan includes constructing nine 56-foot-wide sector gate structures in various waterways, one 125-foot floodgate in the Gulf Intracoastal Waterway (GIWW) near Bayou Lafourche, two 125-foot floodgates in the GIWW near Houma, a 200-foot-wide and 1,200-foot-long lock structure in the Houma Navigation Canal (HNC), and new discharge pipes for six existing pump stations. The plan also includes twelve sets of 6-foot by 6-foot concrete box culverts through the levee to allow tidal ebb and flow. Mitigation features in the plan include the creation of 1,352 acres of marsh habitat and widening 10,600 feet of Minors Canal by 40 feet. Consistent with reducing hurricane and storm damages in an environmentally sustainable manner, the project will be designed and operated to achieve coastal wetland conservation through the improved distribution of freshwater inflows to wetlands wherever feasible. The specific designs and operating plans will be formulated in consultation with the interagency habitat evaluate team."*

1.4 Project History

Table 1-1 provides a timeline of authorizations and studies related to the Morganza to the Gulf and HNC lock projects. Many of the report documents are available online at www.mvn.usace.army.mil/prj/mtog/.

Table 1-1. Timeline of Morganza Authorizations and Studies

Morganza to the Gulf of Mexico Timeline	
1992	Reconnaissance study authorized by resolution adopted April 1992 by the Committee of Public Works and Transportation of the U.S. House of Representatives.
1994	USACE completed the Morganza to the Gulf reconnaissance report (USACE, 1994).
1995	In the Energy and Water Development Appropriation Act of 1995 (PL 103-316), Congress directed the USACE to consider the interrelationship of studies and projects that impact the coastal area of Louisiana, including the Morganza feasibility study, the Lower Atchafalaya Basin reevaluation study, and several projects being pursued under the Coastal Wetlands Planning, Protection, and Restoration Act, and directed the USACE to consider improvements at and/or within the HNC. The Feasibility Cost Share Agreement was executed in June 1995.
1996	Section 425 of WRDA 96 (PL 104-303) required the USACE to develop a study of the HNC lock as an independent feature of the Morganza to the Gulf project.
1997	USACE completed the HNC lock study, which recommended a 200-ft wide lock in the HNC south of Bayou Grand Caillou and concluded that a lock structure would provide direct and indirect benefits to the environmental (marsh) habitat in the study area (USACE, 1997). The report recommended that the HNC lock continue to be investigated as part of comprehensive Morganza to the Gulf hurricane and storm damage reduction plans and that the detailed design phase of the lock be expedited and proceed concurrently with the feasibility study.
1998	Congress authorized the USACE to initiate detailed design of the multipurpose HNC lock.
2000	The Morganza to the Gulf of Mexico project was conditionally authorized in WRDA 2000 at a cost of $550 million subject to having a favorable Chief of Engineer's report completed by December 2000; however, the terms of this conditional authorization were not met. The PED phase on the HNC lock complex was initiated in advance of the PED phase for the Morganza to the Gulf of Mexico hurricane and storm damage reduction project. The PED Agreement for the HNC lock was signed in January 2000.
2002	The Morganza to the Gulf feasibility study and PEIS were completed in March 2002 (USACE, 3/2002). The PED Agreement for the overall project was signed in May 2002. In August 2002, the USACE issued a Chief of Engineers report (USACE, 9/2002).
2003	In July 2003, the USACE issued a supplemental Chief of Engineers report (USACE, 2003), which made changes to the non-Federal sponsor's in-kind services.
2004	Section 158 of the Energy and Water Development Appropriations Act, 2004 (Public Law 108-137) authorized construction on Reach J-1, which had been previously identified as work-in-kind.
2005	The PED Amendment 1 executed in March 2005 combined the two PED efforts into one and allowed the non-Federal sponsor to advance funds on the combined PED effort.
2007	WRDA 2007 authorized the Morganza to the Gulf of Mexico, Louisiana project for hurricane and storm damage reduction at a total cost of $886.7 million.
2008	A recon-level analysis and programmatic cost estimate (ARCADIS, 2008) was completed to determine whether or not there would still be a Federal interest in the project with post-Katrina interim criteria (USACE, 2007) incorporated and whether a feasibility-level PAC report should be initiated. Based on an analysis of four alternatives, the general alignment strategy for the PAC report was determined, but not the final level of risk reduction. Phase I Design for the HNC lock and floodgate was finalized in a 50 percent Design Documentation Report (URS, 2008).
2011	The PED Amendment 2 executed in January 2011 increased the funding ceiling and changed the name of the non-Federal sponsor from Louisiana Department of Transportation and Development (DOTD) to the Louisiana Coastal Protection and Restoration Authority.
2012	Legislation changed the former Office of Coastal Protection and Restoration (OCPR) to the Coastal Protection and Restoration Authority (CPRA) and changed the former Coastal Protection and Restoration Authority (CPRA) to the Coastal Protection and Restoration Authority Board (CPRAB).

1.5 Policy, Procedural, and Design Criteria Changes since Authorization

Several policy, procedural, and design criteria changes have been made since the 2002 Morganza to the Gulf Feasibility Report was completed. Lessons learned from Hurricane Katrina and other recent storms have been incorporated into engineering criteria. New guidelines referred to as the Hurricane and Storm Damage Risk Reduction System Design Guidelines (USACE, 2/2011), or "HSDRRS criteria," have been incorporated into the Morganza to the Gulf project for this PAC report as required by the Assistant Secretary of the Army (Civil Works) for all hurricane levee system work in the New Orleans District. Some design criteria that are more stringent than required for other USACE structures. Changes leading to larger levees and structures, and higher costs, include the following:

- **Increase in Hydraulic Design Elevations –** Storm surge modeling in the 2002 report was based on only 17 tropical storms and did not consider relative sea level rise in the model. New storm surge modeling predicts water levels based on 115 theoretical storms and incorporates the effects of relative sea level rise within the model. In addition, the 1 percent annual chance exceedance water levels in the 2002 report were based on the 50 percent confidence values, which have a 50 percent chance of being under-predicted. The new design guidelines require levees to be designed based on the 90 percent confidence values, which have only a 10 percent chance of being under-predicted. All of these factors result in prediction of higher surge and waves, and wave run up used to set levee elevations.
- **Change from I-Walls to T-Walls –** In the 2002 report, floodwalls could be based on I-wall designs. Under the new guidelines, I-walls are not permitted in most cases and have been replaced with more robust and more expensive T-walls.
- **Increase in Geotechnical Stability Factor of Safety –** The analysis method for global stability changed, leading to a higher factor of safety, resulting in taller and wider levees and cost increases.
- **Addition of Structural Superiority –** All new structures that are difficult to construct because of disruptions to navigation or traffic, large utility crossings, or requiring cofferdams must be designed with a minimum of 2 ft of additional wall height resulting in cost increases.

In addition, new regulations on risk and sea level change have been issued since 2002 as discussed in the following sections.

1.5.1 Changes in Risk Reduction Levels for Authorized Design Elevations

The pre-Katrina levee elevations for the 2002 Morganza to the Gulf project are based on outdated storm and levee design information, resulting in a project that is unable to provide the 1% AEP level of risk reduction. The first step in assessing the authorized project's current level of risk reduction was to convert the 2002 feasibility report stillwater elevations from the National Geodetic Vertical Datum (NGVD) to the current North American Vertical Datum (NAVD88 epoch 2004.65). The next step was to perform a statistical analysis on each levee reach, which determined that a 3% AEP level of risk reduction best describes the 2002 Chief's Report Plan. For the PAC report, the 2002 Chief's Report Plan was subsequently redesigned based on the current projected 3 percent annual chance exceedance surge elevations. The PAC addresses the civil and structural improvements required to achieve the pre-and post-Katrina designs (3% and 1% AEP) as per the HSDRRS guidelines (USACE, 2/2011).

1.5.2 Risk and Uncertainty Guidance

Risk and uncertainty are intrinsic in water resources planning and design. Engineering Regulation (ER) 1105-2-101 provides guidance on the risk evaluation framework to be used in USACE flood damage reduction studies. In a coastal environment, flood risk can be caused by a combination of hurricane surge, waves, wave overtopping of structures, riverine flooding due to rainfall and/or snowmelt, or other sources. Unlike areas located along major rivers such as the Mississippi River or Atchafalaya River, in the Morganza to the Gulf project area, the dominant source of flood risk is from hurricane storm surge and waves. Both storm surge and waves are taken into account in proposed levee designs, however, the risk analysis has been simplified as "the probability an area will be flooded by storm surge, resulting in undesirable consequences."

ER 1105-2-101 requires project performance to be described in terms of annual chance or exceedance probability and long-term risk, rather than level-of-protection. A '100-year level-of-protection levee' is often misunderstood to mean a levee that defends against a storm surge that is only expected once every 100 years. In terms of annual chance or exceedance probability, a 100-year levee is designed to withstand a storm surge that has a 1 in 100, or 1 percent, chance of occurring in any given year, not a storm surge that occurs only once every 100 years. For this reason, the terminology '100-year' has been changed to the '1% AEP.'

For investment decisions, risk is typically evaluated in annual probabilities, but when considering the value of levee investments and the assets behind them, one year is short term. Although the 1% AEP levee design has a low probability of being exceeded in any given year, the probability increases the longer the timeframe considered. For the average person's mortgage (30 years), the probability of the 1% AEP flood occurring is 26 percent. For the average person's life, the probability is greater than 50 percent.

Table 1-2. Comparison of AEP and Long-Term Risk

Example Alternative Design Level	Annual Chance of Exceedance	Annual Probability of Exceedance	Long-Term Risk (Probability of Exceedance Over Indicated Time Period)				
			10 Years	30 Years	50 Years	70 Years	100 Years
No Action	1 in 10	0.10 or 10%	65%	96%	99%	100%	100%
3% AEP Design	1 in 35	0.03 or 3%	25%	58%	77%	87%	94%
1% AEP Design	1 in 100	0.01 or 1%	10%	26%	39%	51%	63%
0.2% AEP Design	1 in 500	0.002 or 0.2%	2%	6%	10%	13%	18%

Table 1-2 provides an example of long-term risk for several design levels. The 10% AEP is an example of the no action condition in some locations; the actual AEP varies by location within the study area. Similarly, the 3% AEP and 1% AEP system designs do not result in a consistent AEP in every location. Actual AEP depends on factors unique to every location including elevation, hydrology, presence of local levees, etc.

1.5.3 Sea Level Change Guidance

Recent climate research by the Intergovernmental Panel on Climate Change predicts continued or accelerated global warming for the 21st Century and possibly beyond, which will cause a continued or accelerated rise in global mean sea level. Sea level change can cause a number of impacts in coastal and estuarine zones, including changes in shoreline erosion, inundation or exposure of low-lying coastal areas, changes in storm and flood damages, shifts in extent and distribution of wetlands and other coastal habitats, changes to groundwater levels, and alterations to salinity intrusion into estuaries and groundwater systems. Impacts to coastal and estuarine zones caused by sea level change must be considered in all phases of Civil Works programs. Engineering Circular (EC) 1165-2-212, *Sea-Level Change Considerations for Civil Works Programs,* which replaced EC 1165-2-211, provides guidance for incorporating the direct and indirect physical effects of projected future sea level change in managing, planning, engineering, designing, constructing, operating, and maintaining USACE projects and systems of projects. Feasibility level designs, cost estimates, and benefit-cost ratios for the PAC report alternatives are based on an Intermediate Relative Sea Level Rise (RSLR) scenario of 2.4 ft. The effects of the Low (Historic) or High RSLR scenario were also evaluated, consistent with EC 1165-2-212.

1.6 Non-Federal Sponsor

The Louisiana Coastal Protection and Restoration Authority Board (CPRAB) and the Terrebonne Levee and Conservation District (TLCD) intend to be non-Federal co-sponsors for the Morganza to the Gulf project (hereafter referred to as the non-Federal sponsor). In a letter dated 21 December 2012, the non-Federal sponsor expressed commitment and understanding of non-Federal cost share responsibilities for construction and operation and maintenance, repair, replacement and rehabilitation (OMRR&R). Section 1001(24) of WRDA 2007 specifies Federal responsibility for OMRR&R of the HNC lock complex and the GIWW floodgate features that provide for inland waterway transportation in accordance with Section 102 of WRDA 1986, as amended. The non-Federal sponsor is responsible for OMRR&R of all other project features. Additional responsibilities of the non-Federal sponsor are listed in section 8.3 of this report.

1.7 Funding and Cost Share

Federal and non-Federal cost share proportions change as a USACE Civil Works project progresses from the feasibility phase to PED to construction. Expenditures for the completed Morganza to the Gulf feasibility study were $9,320,000, which was cost shared 50 percent Federal and 50 percent non-Federal.

Approximately $61,650,000 has been allocated for PED, which includes the PAC report, however, most of the PED funds have been spent on engineering design and geotechnical investigations since 2003, rather than on the PAC feasibility-level analysis. Per USACE guidance, study costs for the PAC report are being cost shared 75 percent Federal/25 percent non-Federal. The PAC study is being cost shared under a Design Agreement originally executed on 22 May 2002, amended on 24 March 2005, and amended again on 11 January 2011. While the Design Agreement provides for 75/25 cost share during design, WRDA stipulates that the non-Federal share of the cost of design is the same percentage as the non-Federal share for construction, which in this case is 35 percent. The design cost is shared per the percentage of construction cost with 25 percent being collected from the non-Federal sponsor during the Design Agreement and the remaining 10 percent collected in the first year after the Project Partnership Agreement (PPA) is executed.

Pending re-authorization, the construction cost share would be 65 percent Federal and 35 percent non-Federal. No Federal funds have been appropriated for construction of the Morganza to the Gulf project.

1.8 Non-Federal Sponsor Work Independent of the Federal Authority

The 2003 Chief's Report and 2004 Energy and Water Development Appropriations Act specified two floodgates and 21.5 of the original 72 miles of levee in the authorized project for in-kind credit. The July 2003 supplemental Chief's Report listed features that *may be designed, constructed, or managed during construction by the sponsor with in-kind services* as follows:

- *A 56-foot-wide floodgate on Bayou Pointe au Chien[1];*
- *A 56-foot-wide floodgate on Bush Canal;*
- *A 14-foot-high and 12-mile-long levee from the Bayou Pointe au Chien floodgate to the Humble Canal floodgate, and the structures therein;*
- *A 14-foot-high and 6.5-mile-long levee from the Bayou Petite Caillou floodgate to the Bush Canal floodgate, and the structures therein; and,*
- *A 14-foot-high and 3-mile-long levee from the Bush Canal floodgate to the Bayou Terrebonne floodgate and the structures therein.*

Reach J-1 was separately authorized for construction in advance of the Morganza to the Gulf project. Section 158 of the 2004 Energy and Water Development Appropriations Act (Public Law 108-137) authorized construction of Reach J, Segment 1 (J-1) at a total cost of $4,000,000.

> *"The Secretary may carry out the Reach J, Segment 1, element of the project for hurricane and storm damage reduction, Morganza to the Gulf of Mexico, Louisiana, in accordance with the report of the Chief of Engineers, dated August 23, 2002, and supplemental report dated July 22, 2003 at a total cost of $4,000,000."*

In order to receive credit for in-kind work, the non-Federal sponsor must sign a PPA with the Department of the Army prior to the work being undertaken by the project sponsor. A PPA has not been signed by the sponsor and the Army. The non-Federal sponsor has started work on reaches that were initially proposed to be a part of the Morganza to the Gulf project, at their own expense, acknowledging that there is no signed PPA in place. The sponsor has substantially completed approximately 9 miles of what would amount to first lift levees and a few floodgates located along the proposed Morganza to the Gulf project alignment. Discussion of those features is included in section 2 of this report.

In the absence of an executed PPA, the locally constructed levees do not form an integral part of the Morganza to the Gulf project, and the work performed by the non-Federal sponsor is not eligible for consideration and approval of work-in-kind credit. The non-Federal sponsor will be entitled to LERRDs credit for the real estate acquired for those local levees to the extent that real estate is required for the Morganza to the Gulf project. In order for the non-Federal sponsor to be eligible to receive a credit for levee construction that took place in advance of the execution of the PPA, Congress would have to enact express authority authorizing the USACE to consider and approve such a credit upon a finding that the levees meet USACE engineering criteria, are economically justified, and environmentally acceptable.

1 Pointe au Chien and Pointe aux Chenes are used interchangeably throughout the report. The community of Pointe aux Chenes was Pointe au Chien until community members had the legislature make a name change in the late nineties. Various features mentioned throughout this report such as the bayou, the proposed floodgate, the Wildlife Management Area (WMA) may be spelled differently but all refer to the same area.

1.9 Related Projects

Some of the most heavily used navigation waterways in Louisiana are located within the project area, including the Federally-maintained HNC and GIWW. Other major water resource projects in the vicinity include the Larose to Golden Meadow hurricane and storm damage reduction project and several ecosystem restoration projects. Table 1-3 summarizes projects most relevant to the Morganza to the Gulf project. Additional details are provided in the RPEIS.

Table 1-3. Projects, Programs and Reports Related to Morganza to the Gulf

	Name	Relationship to Morganza
Navigation Projects	Gulf Intracoastal Waterway (GIWW)	The GIWW runs contiguously through the Morganza to the Gulf project area from Bayou Lafourche at Larose through Houma and on to the Atchafalaya River. The Morganza to the Gulf hurricane levee system crosses the GIWW in two locations requiring floodgates. The GIWW has an authorized depth of 12 ft.
	Houma Navigation Canal (HNC) Deepening Study	The 40-mile HNC connects Houma and the GIWW directly to the Gulf of Mexico. Oil and gas industries in Houma rely heavily upon the channel. In accordance with USACE planning regulations, Morganza to the Gulf plans must assume that the current authorized depth of the canal, -15 ft, will remain as currently authorized in the future; however, there is the possibility that the HNC will be deepened in the future given the preliminary results of an ongoing HNC Deepening Study.
Storm or Flood Damage Reduction Projects	Larose to Golden Meadow Hurricane and Storm Damage Reduction Project	The eastern endpoint of the Morganza to the Gulf authorized levee ties into the existing 43-mile Larose to Golden Meadow ring levee system. The Larose project was originally authorized to provide the 1% AEP level of risk reduction, but is currently undergoing a PAC analysis to ensure that completion of project features are in compliance with post-Katrina guidelines.
	Terrebonne Levee Conservation District (TLCD) Levees	The levee district currently operates approximately 92 miles of levees along with several pump stations and floodgates. In addition, the levee district has recently started building components of the authorized Morganza to the Gulf project, including 9 miles of first-lift levees and interim barge gate structures on several critical bayous.
Ecosystem Restoration Programs	Louisiana Coastal Area (LCA) Program	Several LCA projects authorized by WRDA 2007 are located within the Morganza study area, including but not limited to: (1) Convey Atchafalaya River Water to Northern Terrebonne Marshes and Multipurpose Operation of Houma Navigation Lock (2) Modification of Davis Pond Diversion and (3) Land Bridge between Caillou Lake and Gulf of Mexico. By letters dated 20 August 2012 and 16 October 2012, CPRAB has notified the Corps that it desires to suspend study and design on these projects. The decision of CPRAB to suspend these projects results in some degree of uncertainty regarding implementation of these projects as part of the authorized Federal LCA. For more details, see section 10.1.7, LCA Program Uncertainties.
	Coastal Impact Assistance Program (CIAP)	The CIAP Falgout Canal Freshwater Enhancement Project is located along the proposed footprint of Morganza Levee Reach E. The goal of the project is to improve efficiency of freshwater flow and to restore salinity to levels that are favorable for fresh and intermediate marsh within the basin. Morganza Reach E includes culverts that would provide similar benefits.
	National Estuary Program	The Barataria-Terrebonne Basin was selected for the National Estuary Program in 1990. The program is cost-shared by the U.S. Environmental Protection Agency (USEPA) and Louisiana's Wetlands Conservation and Restoration Trust Fund.
Multi-Purpose Coastal Plans	Louisiana Coastal Protection and Restoration (LACPR) Final Technical Report	The LACPR technical report includes a coast-wide analysis of a multiple lines of defense approach to “Category 5” risk reduction. The report includes structural measures, such as floodgates, floodwalls, and levees, nonstructural measures, such as elevating homes, and coastal restoration measures, such as diversions and marsh restoration. LACPR technical data was used in the preliminary post-authorization analysis of Morganza alternative alignments.
	Louisiana’s 2012 Coastal Master Plan	In the first implementation period (2012-2031) of its 50-year coastal master plan (2012-2061), the State of Louisiana recommends constructing the Morganza to the Gulf hurricane storm surge risk reduction project at the 1% AEP design elevations.

2 Risk-Based Inundation Reduction Benefits Analysis

Most benefits from a hurricane and storm damage reduction project result from the reduction of actual or potential damages due to inundation. Physical inundation reduction damages include damages to residential and commercial structures, losses to the contents in those structures, and damages to privately owned automobiles. Inundation reduction benefits on both existing and future development were considered for project justification.

2.1 Analysis Years

The period of analysis begins with day 1 of the base year and extends generally 50 years for USACE projects. The National Economic Development Procedures Manual, Institute of Water Resources Report 93-R-12 excludes the construction or implementation period from the period of analysis. Early in the PAC study, the 50-year period of analysis was defined as 2035 to 2085. The base year was set based on the assumption that 2035 would be the soonest that the Morganza to the Gulf project constructed to post-Katrina design standards could achieve the 1% AEP level of risk reduction.

Project construction is expected to take place over many years and would result in a closed system providing partial risk reduction prior to achieving the full base year level of risk reduction. It was determined that both alternatives could achieve a closed system by 2024, which provides benefits during construction. Therefore, Hydrologic Engineering Center Flood Damage Analysis (HEC-FDA) models were developed to represent existing conditions (2010), pre-base year conditions (2024), base year conditions (2035), and future year conditions (2085). Outputs from each model are then interpolated to develop annual damage and benefit results.

2.2 Reaches

The PAC report refers to two types of “reaches” as follows:

- **Levee reaches** are segments of the proposed Federal hurricane levee. For the risk analysis, the Morganza levee was divided into major reaches designated by a letter (e.g. J). For detailed design, some of the levee reaches are further sub-divided (e.g. J-1, J-2, J-3).
- **Economic reaches** are sub-areas within the overall study area. Each economic reach has an assigned stage-probability relationship, which is used to calculate damages and benefits. For purposes of planning and analysis, the Morganza study area was originally divided into 276 economic sub-areas or reaches (see Economic Reaches map in Attachment 2). Of the 276 reaches, 264 were determined to be at risk from storm surge. Of the 264 reaches at risk, 234 reaches contain residential and/or non-residential structures; the remainders are open water or wetland areas.

2.3 Datum

The only datum used in the PAC analysis is NAVD88 2004.65. If figures or tables reference older data that was based on a different datum, it is clearly stated.

2.4 Risk and Uncertainty Variables

The HEC-FDA software program was used to perform the risk-based benefits analysis. The HEC-FDA program incorporates risk using statistical Monte Carlo simulations. As required by ER 1105-2-101, risk and uncertainty is explicitly incorporated in the calculation of net benefits for the following variables:

- **Stage Discharge Function Exceedance Probability with Uncertainty.** The probability functions are assigned an equivalent record length in HEC-FDA. The model uses this parameter to derive confidence limit curves/bands.
- **Geotechnical Failure Analysis.** This feature allows the user to assign uncertainty to the structural integrity of the levee based on geotechnical evaluations of existing and proposed levees. Levees can experience different modes of failure. Slope failure is normally the first in a series of events that happen to cause a breach. Based on geotechnical analyses, the probability of failure due to stability was insignificant compared to the probability of failure due to overtopping and erodability. Therefore overtopping rates and erodability were the predominate factors used to define levee performance. Levee performance is captured in the HEC-FDA model by designating the "top of levee" only or with a supporting fragility curve. The "top of levee" is the 100 percent levee exceedance or failure point.
- **Wave Overtopping Analysis.** This feature allows the user to include uncertainty to account for the impacts of wave overtopping when analyzing levees. An analysis was completed outside of the software and incorporated by entering the computed failure height as the top of levee elevation for each levee in HEC-FDA.
- **Economic Variables.** Quantified uncertainty surrounding the following four key economic variables: structure values, contents-to-structure value ratios, first floor elevations, and depth-damage relationships. The HEC-FDA model uses the uncertainty surrounding these variables to estimate the uncertainty surrounding the stage-damage relationships developed for each study area reach.

The geotechnical failure and wave overtopping analyses were based on assessments of prior levee loadings due to hurricane surge in similar coastal areas, and discussions with national geotechnical engineering experts at the USACE Risk Management Center, as well as other geotechnical engineers in the New Orleans District who have had field experience in developing fragility curves during the rebuilding of the levee following Hurricane Katrina. The erosion analysis was developed based on the extensive levee overtopping laboratory test perform for the New Orleans District following Hurricane Katrina. Therefore, the overtopping rate that caused erosion on levees with similar composition was well established.

2.5 Simplifying Assumptions

Net benefits are calculated as "without-project damages" minus "with-project damages." Figure 2-1 depicts the actual without-project conditions (existing local levees and no Federal action) and with-project conditions (existing local levees and proposed Federal levees). Additional details on the without-project condition are provided in section 3. Figure 2-2 depicts the simplified approach used to calculate damages in the certified HEC-FDA model.

Use of the certified HEC-FDA model requires a simplified approach for two primary reasons: (1) Model functionality does not allow more than one levee to be assigned to a single economic damage reach, so both sets of levees could not be directly modeled in HEC-FDA. (2) The overtopping equation in the model applies to river levees and is different than the equation used to calculate overtopping for hurricane and storm damage reduction levees. Instead, overtopping can be calculated outside of the program.

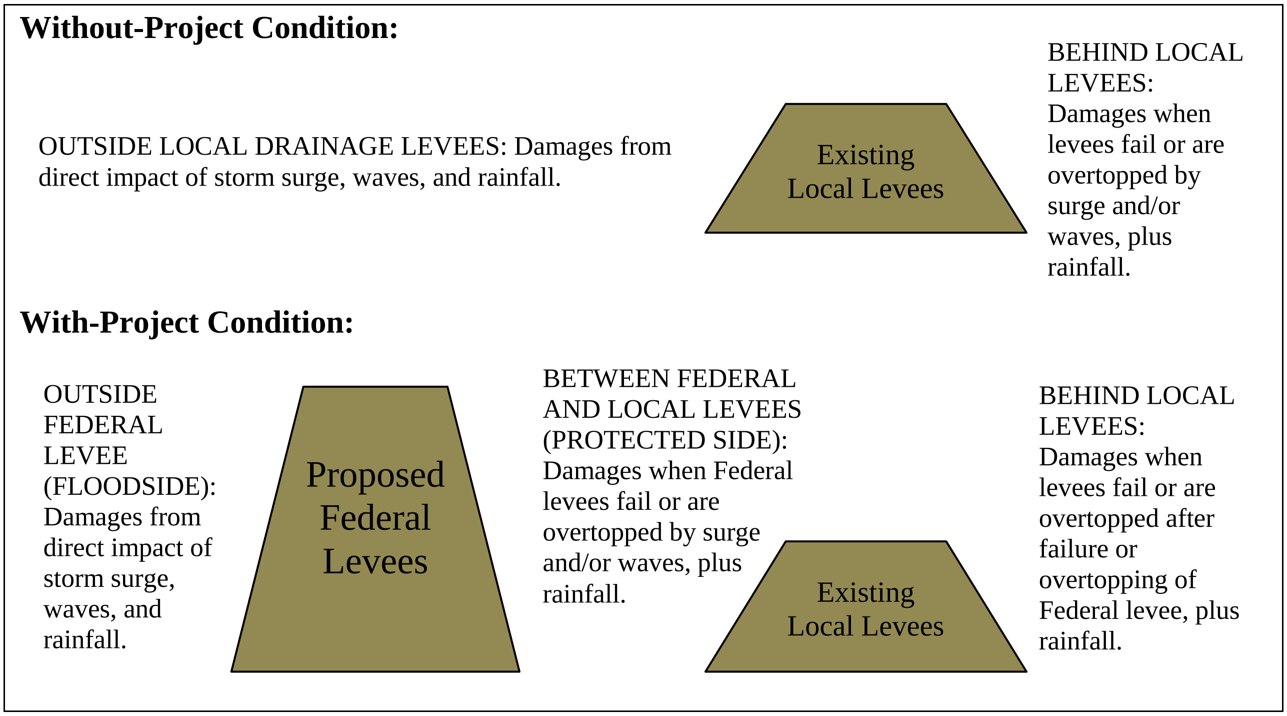

Figure 2-1. Conceptual Depiction of Without- and With-Project Conditions

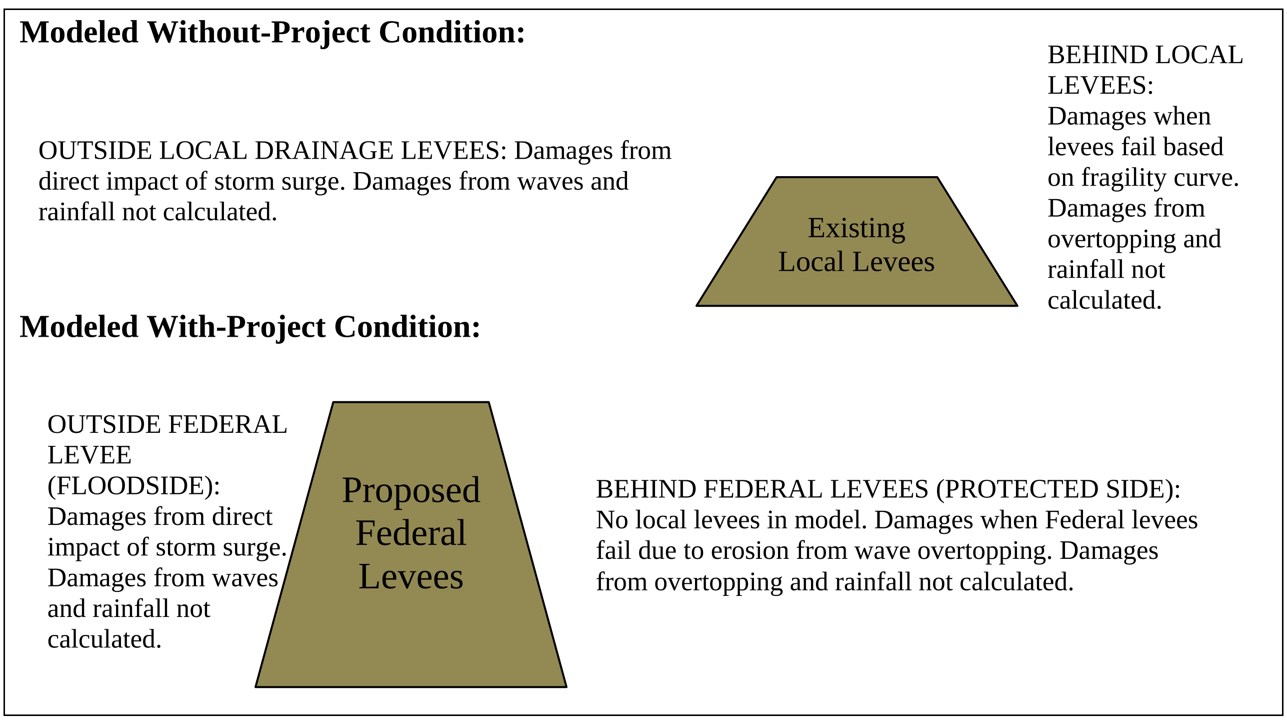

Figure 2-2. Conceptual Depiction of Simplified Conditions in the Certified HEC-FDA Model

Given the simplifying assumptions needed to calculate damages in HEC-FDA, the modeled benefits are expected to be less than the actual economic benefits of the Federal levee for the following reasons:

- Not including the local levees in the with-project condition could overstate residual damages for some types of storm events. In the event of a hurricane event large enough to exceed the Federal design, the performance of the local levees would depend on the location of the breach and how much storage was between the Federal levee and the local levee. As modeled, the volume of water overtopping the Federal levees before failure would not be large enough to raise the interior stages high enough to cause damages. In most cases, the overtopping water would not even reach the local levees. If a hurricane event is large enough to cause a breach in the project levees, then it is assumed the local levees would breach as well; therefore, the impact of not including the local levees in the analysis is minor.
- Ignoring wave damages in both the without- and with-project conditions underestimates damages mostly for the without-project condition, which underestimates benefits of the Federal levee. Surge and/or wave overtopping damages in the with-project condition (where the levee design is not exceeded) are expected to be minimal because of the large storage areas behind most of the Federal levees.
- Erosion of the Federal levee is assumed to occur before the surge still water elevation reaches the top of the levee because of waves on top of the still water elevation. Once the HEC-FDA model determines that an exterior stage (floodside) would cause the Federal design to be exceeded, an exterior/interior relationship defines the interior (protected side) stage. If this relationship is not specified, the HEC-FDA model will use the same stages on the interior as on the exterior. Since the exterior stage would be lower once the levee breaches, a simplifying assumption was that the interior stage will equal the without-project stage once the levee breech occurs. In reality, due to insufficient volume of water and duration associated with a typical hurricane storm surge (short duration), filling the protected area to the without-project elevation is extremely unlikely. The consequences of a hurricane event would be based on a flood elevation that is much lower than the estimated surge elevation. This effect has been validated by observations during Hurricane Katrina in the New Orleans Metro area, New Orleans East, and St. Bernard Parish where the flood elevations in the protected areas were notably lower than the storm surge elevations.

Rainfall is not part of the HEC-FDA model because the hurricane and storm damage reduction levees would not reduce rainfall damages. Impacts of the proposed Federal levee on the interior area were modeled using UNET (Unsteady flow through a NETwork of open channels). No interior drainage improvements are necessary given the large storage areas (e.g. Lake Boudreaux) behind the Federal levee.

2.6 Stage-Probability Inputs

For each of the four HEC-FDA models (2010, 2024, 2035, and 2085), stage-probability inputs were based on the following eight points: 0.999, 0.2, 0.1, 0.05, 0.02, 0.01, 0.005, and 0.002. Except for the 2010 existing conditions model, which does not have a with-project condition, each HEC-FDA model contains two sets of stage- probability data in each of the 264 economic reaches—one for the with-project condition and one for the without-project condition.

Stage-probability values were developed using gage data for the more probable events (lower stages) and surge model results for the less probable events (higher stages). Since RSLR was one of the surge model inputs, the surge model results already reflected RSLR effect on future stages; however, RSLR had to be added to the gage data for future years. The 0.999 (1-year), 0.2 (5-year), and 0.1 (10-year) stages were determined from gage data. The 0.02 (50-year), 0.01 (100-year), 0.005 (200-year), and 0.002 (500-year) stages are based on interpretation of surge model results. The 0.05 (25-year) stages were interpolated between the 0.1 (10-year) and 0.02 (50-year) points. If the surge model did not show surge propagated far enough in the basin to produce a surge elevation in an economic reach, an elevation lower than the invert elevation was reported. The minimum elevation is referenced to Morganza to the Gulf project LiDAR (NAVD88).

2.7 Existing Non-Federal Levees in the Without-Project Condition

Fragility curves describe the performance of existing non-Federal levees in the HEC-FDA model. The fragility curve gives the probability of the levee segment reaching its respective failure limit, conditioned on surge water levels.

There are two types of local levees within the Morganza to the Gulf project area. The first type refers to hundreds of miles of interior levees and/or levee-like features, including local levees, roads, natural ridges, drainage ditch spoil banks, and other non-engineered levees that lie interior to the authorized alignment. These features protect against normal tidal fluctuations, but not storm surge flooding from hurricanes. Of these features, the levee district currently maintains and operates over 90 miles of forced drainage levees along with several pump stations and flood control structures. Private landowners have constructed levee systems to protect their land from frequent flooding; however, private levees are not necessarily subject to regular maintenance. This set of levee features is reflected in the existing condition, and fragility curves were developed for each of the levees and levee-like features that enclose 78 of the 276 storage areas in the Morganza to the Gulf study area.

The second type includes approximately 9 miles of non-Federal levees located along the authorized Morganza to the Gulf alignment in reaches J-1, H-2, and H-3 (refer to the project map in Attachment 1 for the location of these reaches). These levees were constructed by the non-Federal sponsor to meet HSDRRS criteria (USACE, 2/2011) in anticipation of Federal project re-authorization but are not part of the Federal project. Of these 9 miles of levee, only Reach J-1 (elevation +8.5 ft NAVD88), authorized separately for construction under Energy and Water Development Appropriations Act of 2004, was in place in 2008 when the project storm surge modeling was initiated and is included as part of the existing condition. There is a local levee fragility curve associated with levee Reach J-1. Construction of the remaining 6 miles, Reaches H-2 and H-3 (elevation +10 ft NAVD88), did not begin until 2009 and therefore could not be reflected in the without-project condition. Since H-2 and H-3 do not create a closed system (remains open to south, west, and north), their construction would not significantly affect the without-project condition, and there is no fragility curve associated with these two levee reaches.

Levees constructed by the non-Federal sponsor along the Morganza to the Gulf alignment are generally at an elevation less than +12 ft NAVD88 in areas where the Federal levee could eventually be over +26 ft NAVD88. The local levees appear to be constructed to HSDRRS standards (USACE, 2/2011) and would likely promote soil consolidation as a foundation to the Federal project. Floodgates put in place by the non-Federal sponsor (steel barge gates) do not meet HSDRRS standards and would eventually be removed and replaced with sector gates that are part of the Federal project.

Development of fragility curves for the local levees considered two conditions: (1) global stability without overtopping and (2) overtopping with subsequent erosion. The local levees vary in elevations, compositions, top width, and side slopes and are scattered throughout the study area. Local levee elevations range from approximately +3 to +10 ft and have an average elevation of around +6 ft NAVD88. Levee slopes range from 1:10 to 1:3. There is little or no levee design documentation available, so geometric and engineering material properties of the local levees were determined from aerial photographs, Geographic Information System (GIS) overlays, available geotechnical data, extensive interviews with levee district personnel, and best engineering judgment. Stability analysis was performed on the local levees based on this limited information. The results of the stability analysis indicate that the local levee system's probability of failure due to stability or under seepage was relatively low for still water elevations reaching to the top of the levee. Therefore, the fragility curves were primarily based on erosion from wave overtopping, which is expected to be the dominant failure mode.

To construct the fragility curve for each local levee system, calculations were made to correlate surge elevations with overtopping rates, and failure probabilities were then assigned to those surge elevations. Based on the past loading and performance of these local levees for Hurricanes Gustav (August 2008) and Ike (September 2008), the probabilities of levee failure assigned to 0.1 and 1.0 cfs/ft were established based on the best available engineering judgment. Since the levee would begin to erode at an overtopping rate of 0.1 cfs/ft, the surge still water elevation corresponding to this overtopping rate was assigned a failure probability of 45 percent. At an overtopping rate of 1 cfs/ft, the levee could experience catastrophic failure and was therefore assigned a failure probability of 95 percent. The probabilities of failure assigned to the various overtopping rates are very subjective. Most levee performance criteria contain information on flow rate, embankment geometry, material, and vegetation cover and the engineer tries to relate it to probability. Each project is completely different and dependent on the external conditions and forces acting on the levee as well as the levee integrity.

As an example of how the local levee fragility curves relate to actual performance, one reach of local levee has an average levee height of approximately 7 ft. An overtopping computation resulted in a 1.0 to 1.2 cfs/ft overtopping rate at elevation 6.5 ft. The probability of failure in the fragility curve at that elevation is 95 percent, stating that failure is likely or very likely. This levee actually failed during Hurricane Ike with a storm surge height of 6.2 ft. In contrast, this levee reach experienced a storm surge height of 4.9 ft during Hurricane Gustav and did not fail. Based on the local levee fragility curve developed for this reach, at elevation 5.3 ft, the levee has a less than 10 percent chance of failure.

Figures 2-3 and 2-4 are examples of breaches at two locations. There were no levee breaches during Hurricane Gustav. Hurricane Ike produced some severe scour areas, two levee breaches, and a fronting protection failure. Of those damages, only the control structure breaches along the Louisiana Department of Wildlife and Fisheries marsh management levee (Morganza Reach J-2) and a heavy scour area on the west side of Bayou Du Large (Morganza Reach B) fall along the Morganza authorized alignment. All other breaches and scour areas were along local levees that are not planned for incorporation into the Morganza alignment. Morganza Reach J-1, constructed by the non-Federal sponsor, was overtopped but remained fully intact throughout this storm event. There were no initial damages to report on Reach J-1.

Figure 2-3. Breach at West Corner of "Stair-Step" Portion of Montegut Non-Federal Levee

Figure 2-4. Breach at Lashbrook Pump Station on Ward 7 Levee along Boudreaux Canal

Scour has undermined timber fronting protection, allowing water to seep under pump station.

2.8 Proposed Federal Levees in the With-Project Condition

For each major Federal levee reach, a design exceedance elevation is entered in HEC-FDA along with an exterior/interior stage relationship. The design exceedance point is below the actual top of levee based on wave heights, overtopping, and erodability calculations. The design exceedance elevation is set at the still water elevation that equates to 2 cfs/ft wave overtopping. The 2 cfs/ft point was selected based on data from Colorado State University lab testing on grass-covered levees that showed erosion starting at 2 cfs/ft. This approach is conservative in that benefits and project performance are underestimated; the proposed Federal levee is designed to withstand higher surge elevations and some erosion before breaching would occur. Using the actual top of levee, however, would have overestimated benefits and project performance to some extent because there would be more overtopping using the actual top of levee elevations.

3 Without-Project Conditions (No Action)

Existing conditions and modeling methods have changed in the approximately 15 years since the original feasibility analysis was initiated. Some of the major changes include storm surge and wave height predictions, sea level predictions, and updates to the residential and nonresidential structure inventory. Further details on without-project conditions can be found in the RPEIS and Economic and Engineering Appendices.

3.1 Topography and Land Use

The study area lies at the southern end of the Terrebonne Basin and contains a complex of habitat types, including natural levees, lakes, swamps, marshes, and bayous formed from sediments of abandoned Mississippi River deltas. The majority of the study area is undeveloped wetlands and open water. Elevations in the study area range from less than 1 ft near the Gulf of Mexico to approximately 10 ft near Houma, the largest city in the area. The elevation along the bayou ridges is 4 to 5 ft.

The study area is situated within the Barataria-Terrebonne estuary. The marsh habitat in the estuary transitions from fresh marsh in the more northerly portions to intermediate and brackish marshes, and to saline marsh near the coast. The remaining wetlands consist mainly of woody wetlands (primarily bald cypress/tupelo swamps and bottomland hardwood forest). Wetland areas within the hurricane and storm damage reduction system are deteriorating due to subsidence, saltwater intrusion, and storm surge flooding.

Only about one tenth of the study area has been developed. Communities located within the study area include the city of Houma, the towns of Chauvin, Dulac, and Montegut in southern Terrebonne Parish, the towns of Donner and Gibson in western Terrebonne Parish, and the towns of Gray and Schriever in northern Terrebonne Parish. Also included are the towns of Raceland, Lockport, and Pointe aux Chenes in Lafourche Parish and the portion of the city of Thibodaux south of Bayou Lafourche. Agricultural land is primarily used for pasture/hay and sugar cane.

Nearly all residential development occurs along one of the major bayou ridges, which generally do not flood except during extended and/or strong tropical storm events. Future development is expected to remain within forced drainage systems and along the ridges due to the increased costs associated with constructing homes outside of those areas. Very few residential structures are located in marsh; rather, hunting and fishing camps built on pilings are typically found in those areas.

3.2 Coastal Vegetation and Wetland Loss

Wetland loss in coastal Louisiana continues to be a major problem affecting both the ecosystem and storm surge risk reduction. The study area encompasses over half a million acres of vegetated coastal wetlands. The Louisiana Natural Heritage Program, which describes rare, unique, and imperiled plant species and vegetative communities occurring in Louisiana, lists 45 plant species or natural communities as occurring in Terrebonne and Lafourche Parishes. Storm surge exerts widespread stress upon vegetation through the introduction of higher salinity concentrations than are normally present within the study area and by direct erosion of marsh plants and soils. As area marshes convert to open water, vital fish and wildlife habitat, economic benefits, and hurricane and storm damage reduction benefits are lost. While wetlands cannot prevent the devastating effects of major hurricanes such as the recent Hurricanes Katrina, Rita, and Gustav, wetlands can potentially reduce the storm surges associated with smaller tropical storm events.

As shown in figure 3-1, the land trend between 1985 and 2008 was a loss of approximately 2,600 acres per year, which equates to almost 60,000 acres lost over that period. Projecting that loss rate over the next 75 years would be almost 200,000 additional acres lost, which could be even greater with higher rates of sea level rise and/or subsidence.

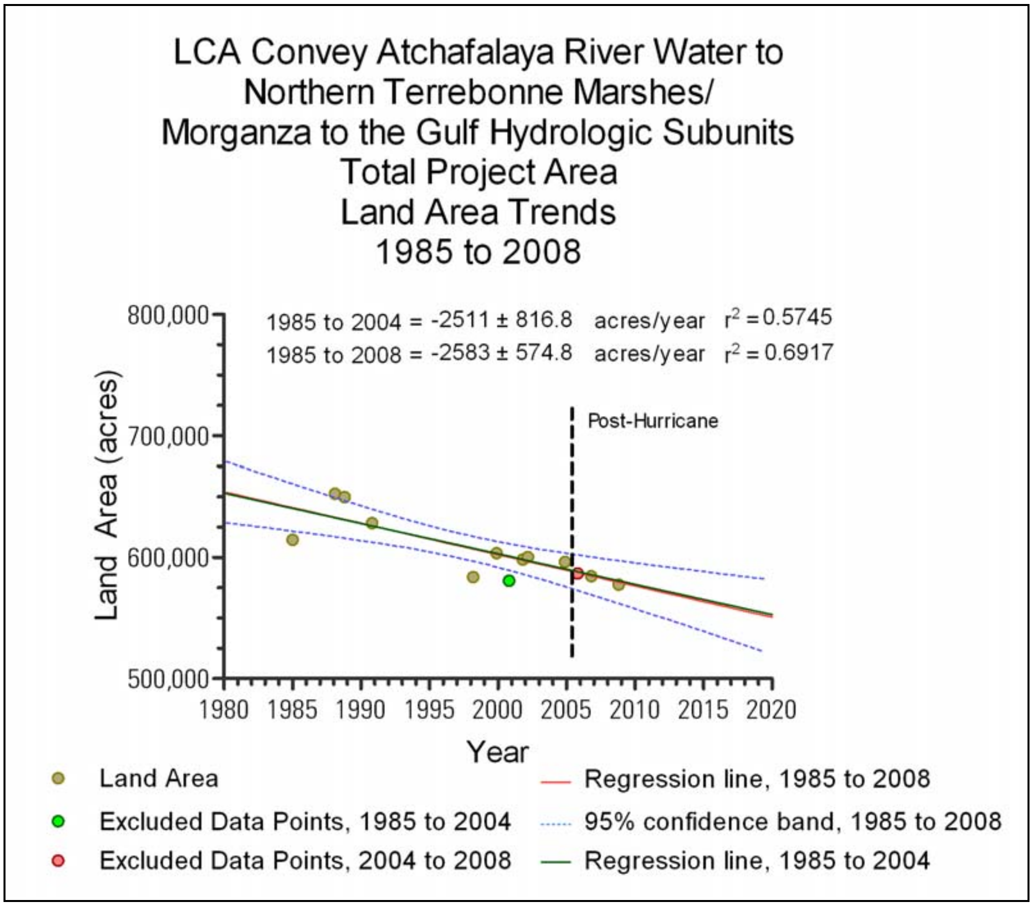

Figure 3-1. Land Area Trends from 1985 to 2008 Projected through 2020

Significant resources may be affected by coastal vegetation and wetland loss including, but not limited to, prime and unique farmland; aquatic resources; fisheries; essential fish habitat; wildlife; threatened and endangered species; water quality; recreation; aesthetics; and cultural resources. For a complete discussion on significant resources, refer to the RPEIS.

3.3 Hurricane Surge and Waves

Since the 2002 feasibility report was completed, Hurricanes Katrina and Rita (2005) and Hurricanes Gustav and Ike (2008) have impacted the study area. Flooding as a result of Hurricane Ike significantly impacted the town of Chauvin, which is located southeast of Houma. The town remained under water for nearly a week after the hurricane, as shown in figure 3-2.

Figure 3-2. Flooding Impacts of Hurricane Ike in Chauvin, Terrebonne Parish

Source: Louisiana Recovery Authority (http://www.lra.louisiana.gov)

Without-project surge and wave modeling was completed in 2008 using 2007 conditions to represent existing/no action conditions. A suite of theoretical hurricanes were modeled within an integrated modeling system to generate storm surge and wave simulations. The ADCIRC Coastal Circulation and Storm Surge Model is coupled with offshore and nearshore wave models (WAM and STWAVE). The ADCIRC surge model used for the Morganza PAC analysis is based on the model that was validated for Interagency Performance Evaluation Task Force (IPET) with Hurricane Katrina data and subsequently validated with data from Hurricane Rita for this and other USACE coastal surge studies. Prior to use of the surge model, modifications to the bathymetry, topography, and levee heights specific to the Morganza study area were made.

The without-project condition was modeled with all existing non-Federal levees and other "levee-like" features in place except for the 6 miles of first lift levees along reaches H-2 and H-3, which were not constructed until after modeling was complete. The without-project conditions do not need to be re-modeled with H-2 and H-3 in place because they do not result in a closed system and would not significantly reduce damages. Storm surge could flank the levee system and/or proceed up uncontrolled bayous and canals, thereby flooding the project area. The constructed first-lift levee reaches are expected to settle within the first couple of years, reducing their ability to protect against a tropical storm surge. If overtopping occurs during a storm event, scour would most likely erode the unprotected side, causing the levees to fail.

Future relative sea level rise was incorporated into surge and wave modeling. Surge propagation over wide, shallow wetland areas is highly sensitive to sea level rise. Increased water depths resulting from sea level rise and wetland degradation can increase surge propagation speed and allow greater inundation. If the mean water level increases in the future, low-lying areas could experience higher surges on average. Waves also generally increased significantly for all sea level rise cases. Wave height increases are significant, but less dramatic than the surge increases.

Three Relative Sea Level Rise (RSLR) scenarios, based on Low (historic), Intermediate, and High sea level rise rates, are part of the risk assessment for the Morganza to the Gulf project. The local historic RSLR trend was determined based on the Leeville, Louisiana gage. Subsidence is included in the gage readings. Applying a linear trend to the 43 years of available data gives a yearly relative sea level increase of approximately 0.3 in/yr. EC 1165-2-212, *Sea-level Change Considerations for Civil Works Programs*, provides the equations for calculation of the RSLR values for the three scenarios. Table 3-1 shows the calculated values for 2010 to 2035 (existing conditions to base year), and for 2010 to 2085 (existing conditions to future year).

Table 3-1. Total Relative Sea Level Rise by 2035 and 2085 by Scenario

Scenario	Total RSLR (ft)	
	Over 25 years: 2010 to 2035	Over 75 years: 2010 to 2085
Low (Historic Rate)	0.6	1.7
Intermediate (Rate 1)	0.7	2.4
High (Rate 2)	1.2	4.8

Since much of the surge and wave modeling for the Morganza to the Gulf PAC was completed prior to issuance of EC 1165-2-212, the modeled RSLR values vary slightly from the EC-calculated values. Simulations were run for approximately 1, 3, and 5 ft of RSLR, and the results were then interpolated for the three RSLR scenarios. Modeling results demonstrated that surge does not increase linearly with sea level rise. Present day surges of 7 to 10 ft could increase by as much as 3 to 7 ft more than the sea level rise increase in the future.

After running storm surge models, results were statistically analyzed to estimate stage-probabilities for the intermediate RSLR scenario (table 3-2).

Table 3-2. Representative Without-Project Surge Still Water Elevations (No Waves)

Frequency	Existing Condition (2010)	Base Condition (2035) Intermediate RSLR	Future Condition (2085) Intermediate RSLR
0.04 (25-yr)	6 to 8 ft	7 to 9 ft	9 to 10 ft
0.02 (50-yr)	9 to 10 ft	10 to 11 ft	11 to 13 ft
0.01 (100-yr)	11 to 12 ft	12 to 13 ft	13 to 15 ft
0.005 (200-yr)	13 to 14 ft	14 to 15 ft	15 to 17 ft
0.002 (500-yr)	15 to 16 ft	16 to 17 ft	16 to 19 ft

Note: Values are rounded to the nearest foot. More detailed information can be found in the Engineering Appendix. Values are for the Intermediate RSLR scenario. See section 6.9 for a discussion on the Low and High RSLR scenarios.

See Attachment 3 for a set of maps corresponding to the 50-, 100-, and 500-yr surge inundation depths for 2010, 2035, and 2085 without-project conditions.

3.4 Local Hydrodynamics and Salinity

The major rivers and their tributaries affecting the study area are the Mississippi River to the east and the Atchafalaya River to the west. Rainfall typically flows away from the major streams and collects between the ridges to form bayous, such as Bayou Lafourche, that flow south toward the Gulf of Mexico. Anthropogenic changes within the study area, such as construction of canals, pipelines, roads, railroads, navigation channels, and levees, have altered the natural flow patterns. Major waterways crossing the study area include the east-west GIWW and the north-south HNC. The HNC has been implicated in higher salinity in the Houma area. The study area also has numerous forced drainage systems that remove excess stormwater by a combination of earthen levees, drainage canals, and pumps.

To determine hydrodynamic and salinity effects, a TABS-MDS numerical model has been created for the Morganza area. The primary freshwater inflows to the system are the Atchafalaya River and the Wax Lake Outlet. Additional smaller inflows (Bayou Boeuf, GIWW at Larose, Bayou Lafourche, and three drainage channels) were also included in the model geometry. Without the project in place, storm surges push seawater from the Gulf of Mexico and increases salinity in the study area. The salinity gradient in the basin varies from 0 ppt in the upper basin to 27 ppt at certain times of the year in the Gulf of Mexico as shown in figure 3-3. Factors affecting salinity in the project area include the Atchafalaya River discharge via the GIWW, Gulf of Mexico salinity and circulation, wind, rainfall/evaporation, tidal exchange, vertical mixing in deeper channels, and bathymetry.

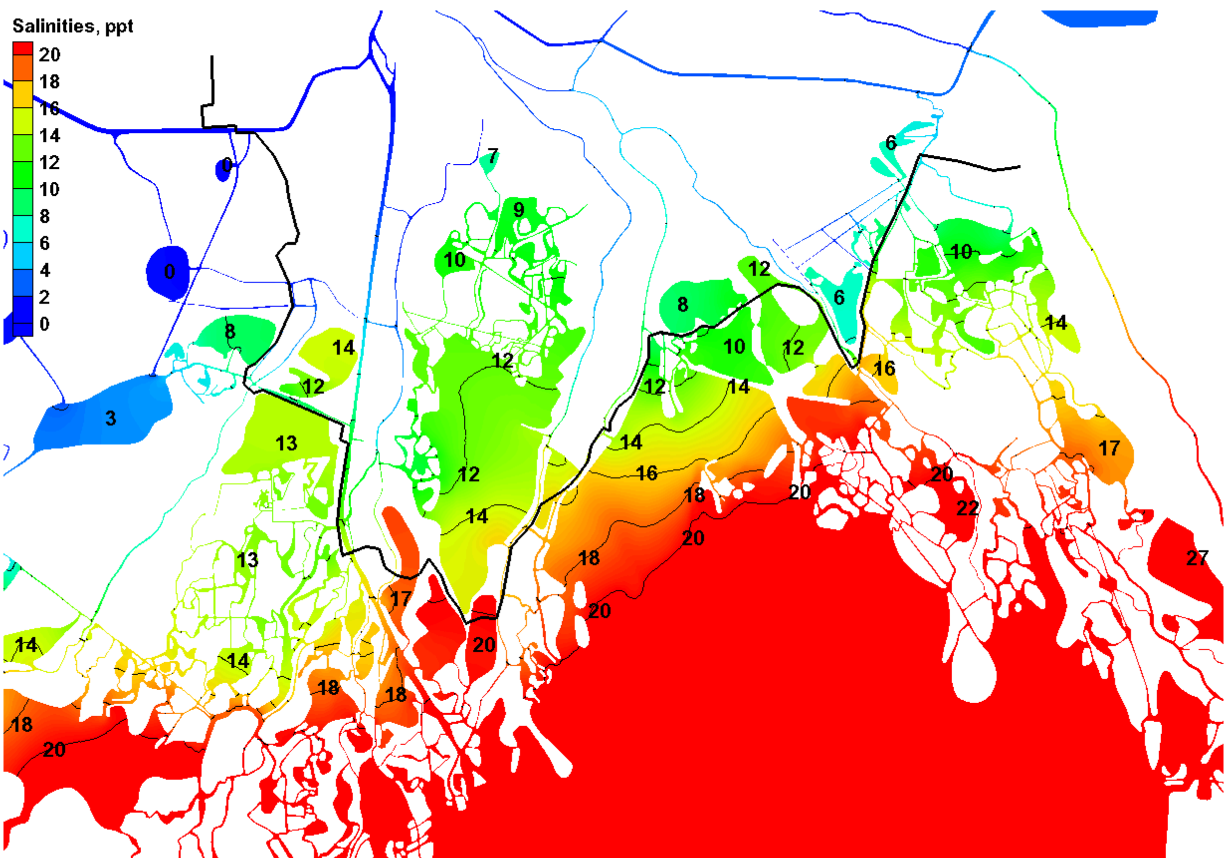

Figure 3-3. Base Average Salinity for October to December 2004 Without-Project Conditions

3.5 Population and Storm Surge Damages

The structure inventory for the original Morganza feasibility study (2002) was collected in 1997-98. To update the inventory for the PAC report, field surveys were collected in 2009. The location of inventoried residential and non-residential structures is shown in figure 3-4. As shown in table 3-3, the number of structures in the study area has more than doubled since the original inventory was collected in 1997/1998 because of population growth and an expansion of the flood risk area.

Since Morganza PAC surge modeling results were not yet available when the inventory was collected, potential damage areas were identified using the largest surge extent developed as part of the post-Katrina LACPR evaluation. In addition to areas outside of the storm surge extent, the area north of Bayou Lafourche between Lockport and Larose was not inventoried because it was originally part of the Donaldsonville to the Gulf study area and was not incorporated into the Morganza to the Gulf study area until after the inventory was collected.

Based on the information collected during the field surveys, a depreciated replacement cost for residential and non-residential structures was calculated. The value of the land was not included in the analysis. A small number of industrial structures were also inventoried using interview forms approved by the Office of Management and Budget.

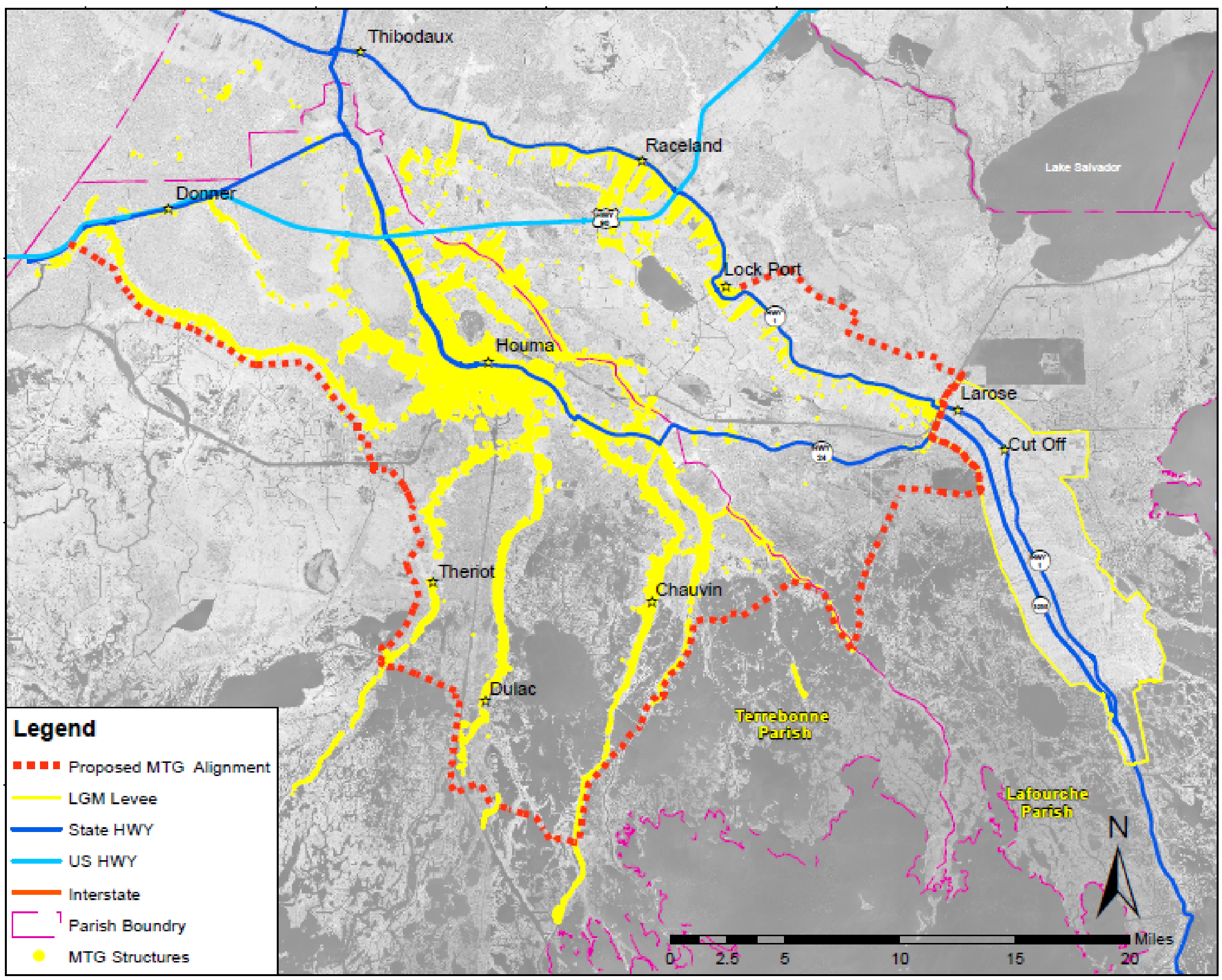

Figure 3-4. Location of Structures in the Morganza to the Gulf Study Area

Table 3-3. Number of Structures Inventoried in 1998 and 2009.

Structure Type	Number Inventoried	
	Updated PAC Survey (2009)	Original Survey (1997/98)
One-Story Slab	21,694	10,146
One-Story Pier	12,723	9,891
Two-Story Slab	1,656	2,399
Two-Story Pier	615	401
Mobile Home	9,859	1,753
Multi-occupancy	See note*	178
Residential Subtotal	**46,547**	**24,768**
Nonresidential Subtotal**	**6,263**	**880**
Total Structures	**52,810**	**25,648**

*In the 2002 feasibility report, multiple-occupancy/multi-family structures were grouped under residential. Multiple-occupancy/multi-family structures are currently grouped under non-residential and there were 309 inventoried in 2009.
**In the 2002 feasibility report, the four nonresidential categories were (1) Agriculture, Mining, Construction, Manufacturing, and Transportation/Communications/Utility sectors (2) Wholesale and Retail sectors (3) Finance/Insurance/Real Estate and Services sectors and (4) Public sector. In 2009, nonresidential structures were subdivided into the following eight categories: Eatery, Professional, Public, Repair, Retail, Warehouse, Grocery, or Multi-Occupancy.

The increase in the number of households that occurred in the two parishes between 1997 and 2009 was commensurate with the population growth experienced by the entire Gulf Coast region during the same period. In 2010, there were approximately 28,800 people residing in the inventoried structures in Lafourche Parish and approximately 104,900 people in Terrebonne Parish for a total of 133,700 residents at risk of storm surge inundation. The population of Lafourche Parish is projected to total approximately 29,300 in 2035 and about 31,200 in 2085. In Terrebonne Parish, the population in this area is expected to total 113,200 in 2035 and 133,800 in 2085.

Historically, hurricanes have not resulted in outmigration from the area (figure 3-5). Despite having experienced numerous flood events, residents have shown an unwillingness to leave the study area, in large part due to economic and cultural ties to the land. The population decline in the mid- to late-1980s was employment-driven (i.e. lack of employment due an oil bust), rather than as the result of Hurricane Juan.

Data from the 2000 Census show that approximately 65 percent of residents in the Lafourche and Terrebonne Parishes lived in the same housing unit as they had in 1995. This percentage ranged from a high of 81 percent in Dulac (southern portion of the study area) to a low of 54 percent in Thibodaux (northern portion of the study area). In comparison, the national percentage of the population residing in the same house in 2000 as in 1995 was 54 percent.

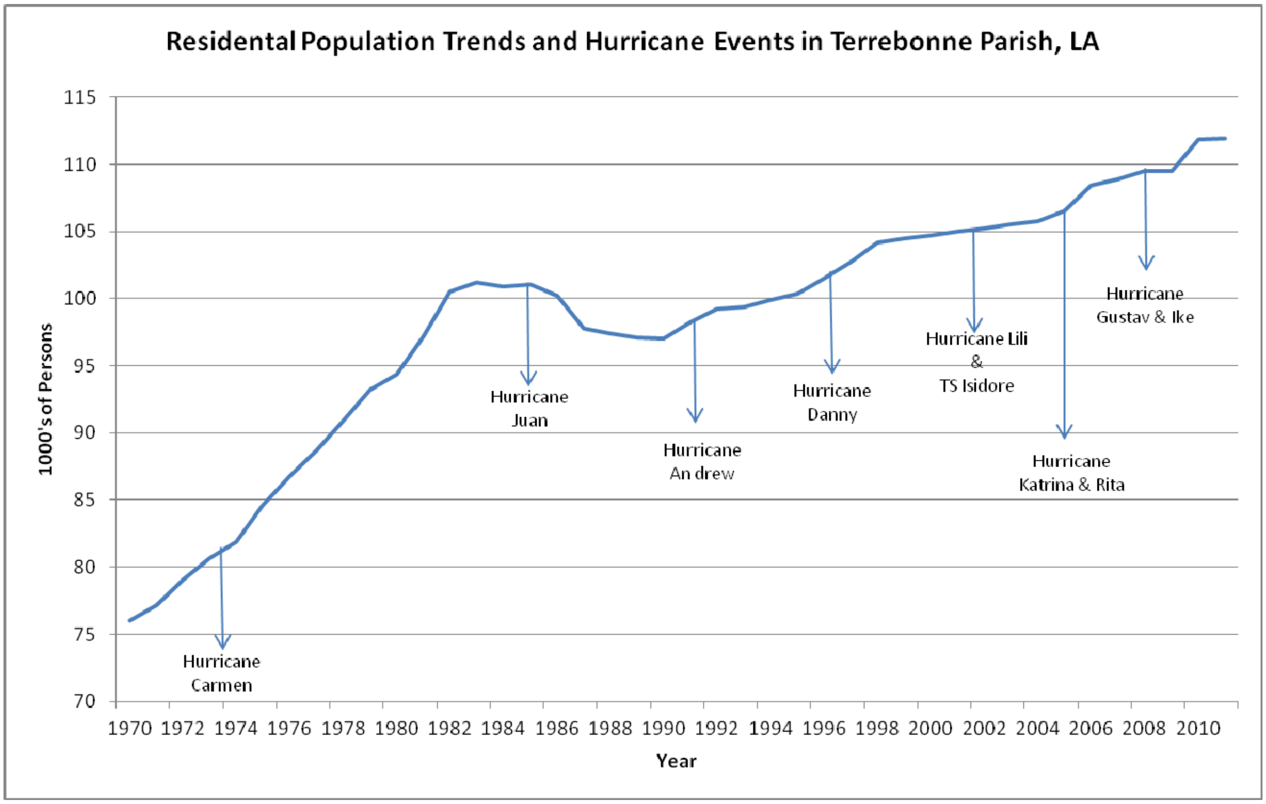

Figure 3-5. Terrebonne Parish Population Trends with Hurricane Events (Source: US Census Data)

According to local officials, residents in low-lying communities began relocating to areas in the northern parts of the study area after Hurricanes Katrina and Rita in 2005. Reasons for this intra-parish shift was a combination of weariness on the part of residents of having to deal with repeat flooding and the more stringent requirements to obtain permits for rebuilding after homes were damaged. In order to rebuild, residents had to incur the cost of building to higher elevations. The ability to secure insurance at a reasonable price was also cited as a reason for the exodus.

The rate of retreat from the southern communities slowed around 2008 after Hurricane Ike impacted the area due to federal assistance, as well as the construction of local levees, which reduced damages to the area. In addition, the two parishes have also implemented elevation programs designed to raise the structures in flood-prone areas. Local officials also stated that residents prefer to remain due to the culture of the residents and the economy of the area. The economy of Terrebonne Parish is closely tied to its abundant natural resources, and many of the residents in the small communities outside of Houma are shrimpers, oystermen, crabbers, fishermen, and trappers. In Lafourche Parish, the economy is strongly tied to the production and distribution of natural gas and oil, commercial fishing, and sugar cane.

The HEC-FDA model used to calculate damages implicitly assumes that all damaged assets are restored to their prior market value completely and within a year after a flood event. Historical data show that major flooding events have not resulted in significant outmigration from the study area, and the post-flood response of property owners is consistent with the HEC-FDA assumption of complete and immediate repair of damaged property. However, the manner in which property owners have responded in the past may or may not be representative of how they will respond in the future to more repetitive and damaging flood events. Even if property owners have been willing to repair flood-damaged property at existing elevations in the past, under future without-project conditions, increased flood risks due to expected relative sea level rise and an increase in the frequency of flooding may result in different post-flood responses over the period of analysis. Property owners could opt to have their structures raised in place, floodproof and/or retrofit their structures, relocate within the floodplain, or permanently evacuate from the study area. The course of action selected by an individual property owner following repetitive flood losses depends upon many factors, including the degree of aversion to future anticipated flood risk by that property owner and Federal, State, and local floodplain regulations.

The initial without-project expected annual damages computed by the HEC-FDA model did not consider the behavior of property owners whose structures incur repetitive flood losses. A breakdown of expected annual damages revealed that there were a significant number of structures with damage exposure from relatively frequent events. Approximately 7,500 residential and non-residential structures would incur flood damages from a 0.1 ACE (10-year) storm event in the year 2035, and approximately 2,000 residential structures would incur damages greater than or equal to 50 percent of the structural value. Given the number of structures at risk from frequent flooding, the magnitude of these damages, and the increased frequency which residential and non-residential structures would be exposed to flooding, adjustments to the implicit assumptions of the HEC-FDA model were deemed necessary. Thus, adjustments were made to the 2024, 2035, and 2085 structure inventories as described in the Economic Appendix.

The preliminary unadjusted expected annual without-project damages ranged from $515 million in 2010 to $1.46 billion in 2085 primarily as the result of increasing stage-probabilities due to relative sea level rise. The final expected annual without-project damages for the adjusted inventories range from $448 million to $1.05 billion in 2085.

4 Initial Reevaluation of the Authorized Plan

In the evolution of the Morganza to the Gulf project, various alternative plans have been developed and evaluated with the goal of maximizing hurricane and storm damage reduction benefits while minimizing costs and adverse impacts to the environment, local interests, navigation, and industry. Engineering, environmental, economic, sociological, and institutional factors have been key considerations in the formulation and evaluation of alternatives. Measures and alternatives that were either not feasible, unacceptable, or did not meet the planning objectives were eliminated from consideration as final alternatives.

This section describes the limited re-evaluation of post-authorization alternatives. Prior to initiation of the PAC analysis in 2008, a recon-level analysis of four alternatives was conducted to determine whether the Morganza to the Gulf project could still provide positive net benefits. The 2008 analysis evaluated the authorized alignment at two levels or risk reduction, and two other levee alignments to see if they would produce higher net benefits than the authorized alignment. The authorized alignment was determined to have the potential to produce the highest net benefits.

4.1 Problems, Opportunities, Goals, Objectives, and Constraints

No changes in problems, opportunities, goals, objectives, and constraints have occurred since the 2002 feasibility report analysis. The primary problem continues to be the flood risk associated with storm surge and waves, which is increasing due to wetland loss, sea level rise, and subsidence. Tropical storms cause widespread flooding of residential and commercial properties resulting in extensive damage and economic losses. Despite local efforts to maintain a system of forced drainage levees, pump stations, and flood control structures, an adequate storm surge risk reduction system is not currently in place. Although the USACE cannot affect the root causes of storm surge and wetland loss, such as hurricanes, sea level rise, and subsidence, it has the opportunity to address some of the problems related to storm surge flooding. The overarching goal is to reduce the risk to people and property in the vicinity of Houma, Louisiana. All project benefits are related to hurricane and storm damage risk reduction. No flood damage reduction, navigation, or ecosystem restoration benefits are quantified for this project.

4.2 Nonstructural Alternatives in the 2002 Report

Nonstructural measures complement structural measures and are an essential part of a comprehensive hurricane and storm damage reduction program (NAS 2009). Nonstructural measures reduce risk without significantly altering the nature or extent of flooding. Examples include flood proofing, relocation of structures, elevation of structures, flood warning and preparedness systems, evacuation plans, public education, zoning, and flood insurance. The WRDA of 1974 (PL 93-251) requires that Federal agencies consider nonstructural measures to reduce or prevent flood damage. Nonstructural measures are the responsibility of not just the Federal government, but also state and local governments and private citizens.

Nonstructural alternatives for direct comparison to the authorized Morganza to the Gulf levee project were not formulated as part of this PAC report. The 2002 Morganza to the Gulf feasibility study showed that hurricane and storm damage problems cannot be solved entirely through nonstructural means for the study area. Large-scale relocation is problematic both socially and economically because homes and businesses would have to be moved considerable distances north to the Houma or Thibodaux areas to remove them from the threat of coastal flooding from the 1% AEP (100-year) storm surge event.

The 2002 feasibility report explored the possibility that some reaches along the bayous might lend themselves to elevation, which would be more socially acceptable than relocation or structural measures. The Bayou du Large, Bayou Grand Caillou, and Isle de Jean Charles areas were initially incorporated into some of the alternatives for the overall hurricane and storm damage reduction project due to the existence of earthen levee systems and residential and commercial development. These areas were later removed from the structural alternatives because it was not cost effective to extend the levee to incorporate them (see figure 4-1).

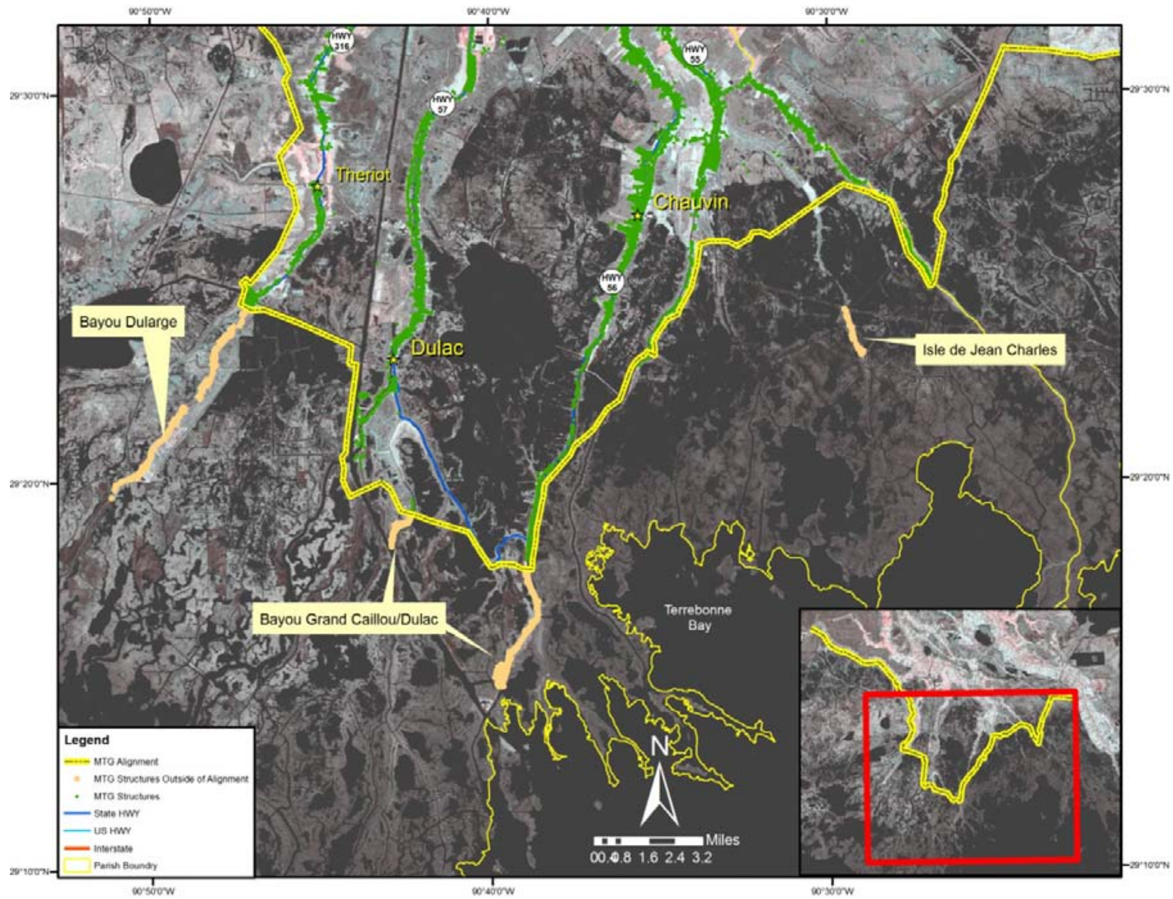

Figure 4-1. Location of Structures Outside of Risk Reduction System

As an alternative to including these areas within the levee alignment, two types of nonstructural measures were considered. For the lower areas of Bayou du Large and Bayou Grand Caillou, alternatives included either raising approximately 6,000 residential structures above the 100-year stage or relocating them out of the 100-year floodplain. Neither nonstructural option for these areas was economically justified so they were eliminated from further consideration.

For Isle de Jean Charles, the only alternative was a buyout and relocation plan since most of the residential structures were already elevated. At that time, the Isle de Jean Charles community included approximately 100 residential structures (currently, there are approximately 70 structures in the Isle de Jean Charles area). The relocation plan was determined to be economically justified; however, it was not recommended as part of the 2002 Morganza to the Gulf project because the proposed plan was not supported by the Isle de Jean Charles community. Instead, the TLCD opted to construct an earthen levee to approximately elevation 6 ft. In addition, the only road to the island was raised to provide a better evacuation route.

For the PAC report, a preliminary nonstructural buyout plan has been developed for high risk areas outside the proposed levee system as described in section 5.5.1.

4.3 Preliminary Evaluation of Alternative Levee Alignments

Following the 2007 WRDA authorization, a set of four Morganza to the Gulf alternatives were evaluated based on post-Katrina/Rita interim design guidelines using LACPR data and methods. The purpose of the 2008 analysis was to determine whether or not there was still a Federal interest in the project and whether a feasibility-level PAC study should be initiated. The four alternatives were developed in 2008 in coordination with the CPRA, TLCD, and a group of non-governmental organizations. The alternative alignments are shown in figures 4-2 through 4-4 and are as follows:

1. Authorized Alignment at Post-Katrina 1% AEP Elevations – Alternative 1 (2008) generally follows the authorized plan alignment; however, it includes a few minor modifications to Reach G that were made between 2003 and 2008. The Reach G modifications are described in section 4.4.
2. Reconnaissance Alignment at Post-Katrina 1% AEP Elevations – Alternative 2 (2008) is based on the "Reconnaissance" alignment from the 2002 Feasibility Report.
3. Multiple Lines of Defense Strategy Alignment at Post-Katrina 1% AEP Elevations – Alternative 3 (2008) is based on a "Multiple Lines of Defense Strategy (MLODS)," presented by a group of non-governmental organizations, which considers the storm buffering potential of natural landscape features such as wetlands as the first line of defense against storm surge and waves. This alignment was not previously considered in the 2002 Feasibility Report. The Alternative 3 alignment includes Theriot and Dulac ring levees. As compared to the other alternatives, the MLODS alignment is located closer to development and has more marsh located outside the levee system.
4. Authorized Alignment at Pre-Katrina Elevations – Alternative 4 (2008) follows the same alignment as Alternative 1 (2008). The authorized project levees, lock, floodgates, environmental facilities, and floodwalls were reengineered to meet post-Katrina design criteria, but not the post-Katrina 1% AEP design elevations. This alternative was evaluated in order to compare the Pre- and Post-Katrina versions of the 2002 Feasibility Study Recommended Plan.

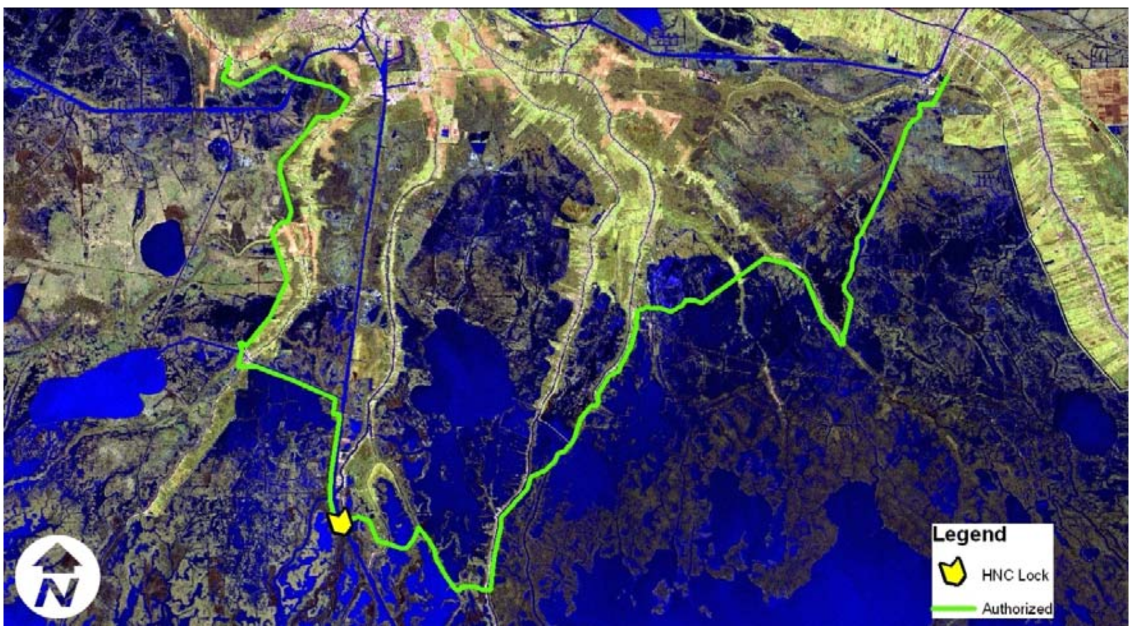

Figure 4-2. Alignment for 2008 Alternative 1 and 2008 Alternative 4

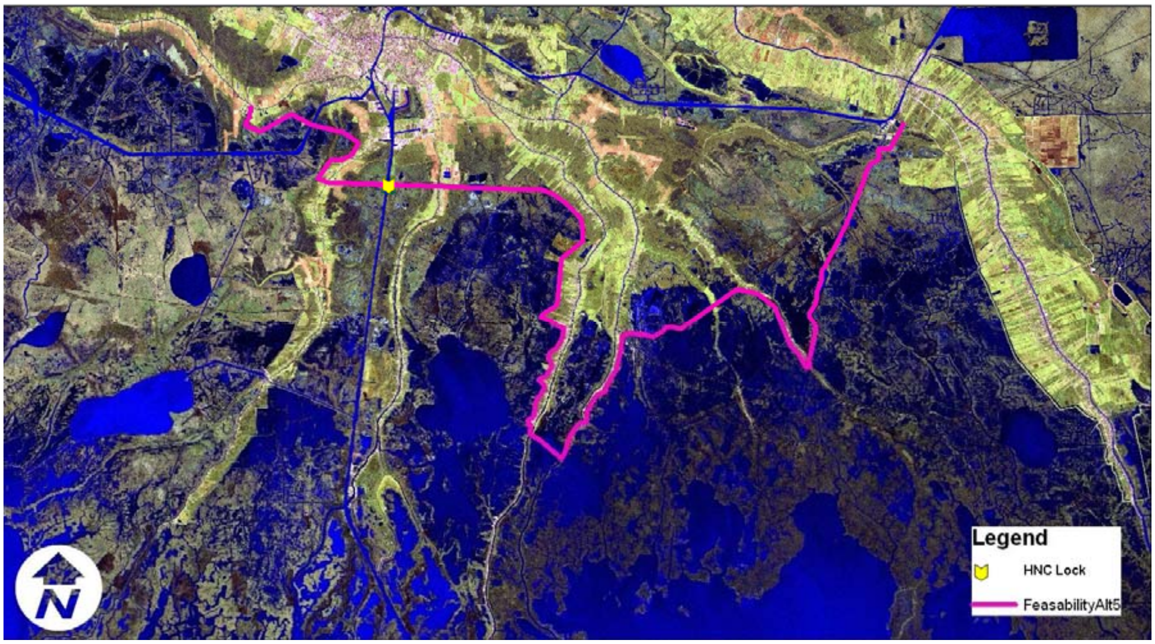

Figure 4-3. Alignment for 2008 Alternative 2

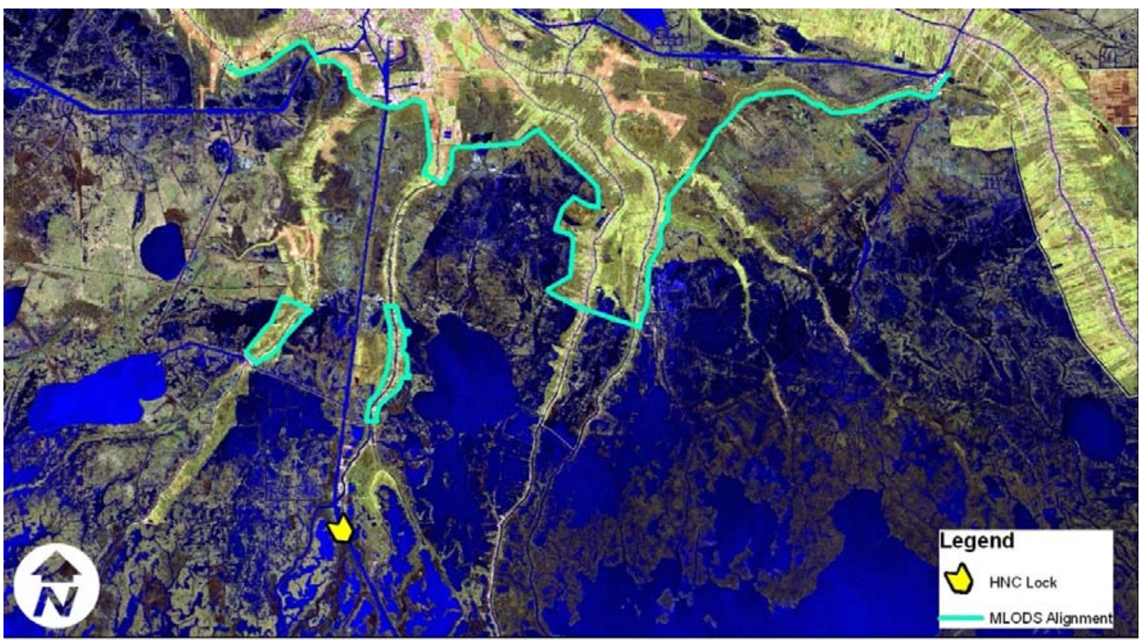

Figure 4-4. Alignment for 2008 Alternative 3

Note: Figure 4-4 (2008 Alternative 3) represents the MLODS alignment as originally proposed; however, the HNC lock would actually be located where the levee alignment intersects the HNC. In addition, a salinity control structure that could be overtopped during hurricane events would be located where the HNC lock is shown on the map.

Table 4-1 presents the results of the 2008 analysis of alignment alternatives. The 2008 analysis was based on the best available information at the time. Interim HSDRRS design criteria (USACE, 2007) available at the time were used. Some major differences between the 2008 analysis and the full feasibility analysis for the PAC report are described following the table.

Table 4-1. Alignment Alternative Comparison of Elements

Feature	2008 Alternative 1	2008 Alternative 2	2008 Alternative 3	2008 Alternative 4
Hurricane and Storm Damage Reduction Design standards (year)	Post-Katrina (2008)	Post-Katrina (2008)	Post-Katrina (2008)	Pre-Katrina (2000)
B/C Ratio (Low to High Scenario)	0.67 to 1.07	0.60 to 0.98	0.49 to 0.79	0.59 to 1.40
Equivalent Annual Net Benefits in $Millions (Low to High Scenario)	($197) to $44	($223) to ($12)	($335) to ($136)	($98) to $99
Estimated Cost (High Scenario)	$ 8.6 B	$ 7.5 B	$ 8.3 B	$ 2.5 B
Levee Length	64.6 miles	55.2 miles	63 miles	64.6 miles
Total Cost per Mile	$133,000,000	$135,700,000	$131,300,000	$38,480,000
Levee Cost per Mile	$81,970,000	$81,270,000	$72,860,000	$17,430,000
Levee Height	Varies 18.5 to 28.5 ft	Varies 18.5 to 28.5 ft	Varies 18.5 to 23 ft	Varies 11 to 15 ft
Low: 14 to 18 ft	0 Miles	0 Miles	0 Miles	64.6 miles
Medium: 18.5 to 24.9 ft	33.3 Miles	29.9 Miles	63 Miles	0 Miles
Tall: 25 ft and over	31.3 Miles	25.3 Miles	0 Miles	0 Miles
Levee Base Width				
Lower Range	524	524	442	164
Upper Range	725	725	680	243
Embankment in Place (CY)	153,089,711	130,674,856	133,708,696	23,936,090
No. Lifts to Construct	Maximum of 5	Maximum of 5	Maximum of 5	Maximum of 3
Marsh Impacted (self mitigated)	5,558 acres	4,953 acres	3,901 acres	1,562 acres
Bottomland Hardwoods Impacted	1,024 acres	1,358 acres	3,776 acres	331 acres
Right of Way Areas	14,527 acres	11,781 acres	13,381 acres	1,614 acres
Stability Berms	Both sides of levee	Both sides of levee	Both sides of levee	Unprotected side only
Nos. of Structures	40	36	40	39
HNC Lock Complex	1	1	1	1
250 ft Sector Gate	0	0	1	0
125 ft Sector Gate	3	3	3	3
56 ft. Sector Gate	10	8	9	10
46 ft. Tainter Gate	5	4	5	5
Sluice Gates	13	14	8	13
Fronting Protection	3	3	3	3
Highway Gates	5	3	10	5

*Benefits and costs are presented for a high damage scenario (high employment, highly dispersed land use, and high relative sea level rise). The without-project equivalent annual damages were estimated at $1.1 billion.

The 2008 designs and costs are based on a typical levee cross-section to elevation +28 ft NAVD88 and representative structure designs. Engineering judgment was applied to scale each typical section higher or lower to match the design elevation provided for each specific hydraulic reach to estimate the required levee footprint, overbuild heights, and estimated lift schedule. The cost estimates (ARCADIS, 2008) include levees, floodgates, the HNC lock complex, tidal exchange/environmental control structures, pumping station fronting protection, road gates, utility relocations, real estate, Engineering and Design, Construction Management, and mitigation for direct impacts to marsh and bottomland hardwoods (wet and dry). A Cost and Schedule Risk Analysis Process was also performed according to guidelines set out by the USACE Walla Walla District in a March 2008 document. Overall, the contingency for the 2008 estimate was calculated to be 23.5 percent at 80 percent confidence level. Since the 2008 analysis, additional borings have been taken to refine structure designs and cost estimates in the final alternatives analysis.

The 2008 economic benefits analysis was based on LACPR data and methods (LACPR, 2009) to calculate damages for the residential and non-residential categories, agricultural resources, transportation infrastructure and emergency cost savings and benefits during construction. The damages to boat fleets and business from saltwater intrusion were based on the 2002 feasibility report. The LACPR census block data was used instead of updated, detailed structure inventory data, which was not available at the time. Economic benefits were calculated using the LACPR GIS database instead of the USACE certified model for performing flood damage analysis, i.e. HEC-FDA.

Annualized benefits and costs were compared over a period of analysis from 2010 to 2081. The assumed base year, when the project would begin to provide the specified level of risk reduction, was assumed to be 2032 for Alternatives 1, 2, and 3 and 2020 for Alternative 4. In order to make the alternatives comparable, the Alternative 4 benefits stream was compounded 12 years from 2020 to 2032 to reflect a common base year (2032) for all four alternatives. Benefits during construction were calculated for all four alternatives. The benefit and cost values were converted to an equivalent time frame using October 2008 price levels and a Federal discount rate of 4-7/8 percent for the amortization period of 50 years.

Reflective of economic evaluations conducted under LACPR, the four alternatives were evaluated under two damage scenarios. The "high" damage scenario incorporates high employment, highly dispersed land use, and high relative sea level rise. The "low" damage scenario incorporates business-as-usual future development, compact land use, and low relative sea level rise.

Preliminary estimates of direct environmental impacts for each of the four alternatives and adjacent borrow sites were developed for the 2008 verification of the authorized alignment. The footprints of project features (levees, adjacent borrow pits, and the mitigation areas) were categorized by land form (wetlands, open water, or non-wet) and a spreadsheet was used to calculate impacts by wetland type (marsh, bottomland hardwood-dry, and bottomland hardwood-wet or "swamp"). All mitigation cost estimates in the PAC report are based on the following:

- Marsh mitigation at $80,000 per acre and a ratio of 1-to-1.
- Bottomland hardwood mitigation at $37,000 per acre and a ratio of 3-to-1, or $111,000 per acre, for bottomland hardwood-wet (swamp) and a ratio of 6-to-1, or $222,000 per acre, for bottomland hardwood-dry.

Wetland replacement ratios are for mitigation cost estimating purposes only; actual mitigation costs would be determined based on replacement of wetland habitat values and ratios could be higher or lower depending on specific habitat type (brackish, fresh, saline, etc).

Indirect impacts were not quantified during the 2008 analysis, but a best professional judgment discussion was held with the interagency team on indirect impacts. Indirect impacts are quantified for the final PAC alternatives as part of the NEPA compliance.

As shown in table 4-1, Alternatives 1 and 4 (2008), which are both based on the authorized alignment, had the highest net benefits among the alternatives and indicated a potential for positive economic justification based upon the results for the high damage scenario. Alternatives 2 and 3 (2008) produced negative annual net benefits under both the high and low damage scenarios. This analysis demonstrates that both alternatives along the authorized alignment potentially remain economically justified, while the alternative alignments examined in Alternatives 2 and 3 (2008) are not likely to be economically justified. Alternatives 2 and 3 were also screened for the following reasons:

- Based on surge modeling, areas outside the levee system may experience higher statistical water levels than without the project. Alternatives 1 and 4 leave fewer assets outside of the levee alignment, most of which are camps or secondary residences. Alternatives 2 and 3 leave many more assets outside the levee system, which has greater implications for induced flooding impacts.
- Alternatives 1 and 4 provide much more internal storage in the case of levee overtopping or significant rainfall during a storm event. Alternatives 2 and 3 would likely require additional pumping capacity and would have higher residual risk in the case of levee overtopping.
- Although Alternatives 1 and 4 enclose more wetlands than Alternatives 2 and 3, the authorized alignment would be mostly constructed along existing raised features (e.g. ridges, local levees, etc.) and the addition of water control features would actually improve the hydrologic exchange in some areas. Although the shorter Alternative 2 and 3 alignments enclose fewer wetlands and have less direct marsh impacts, those alignments actually impact more bottomland hardwoods than the authorized alignment.

For the reasons stated above, the authorized alignment was reconfirmed as the alignment that best meets Federal objectives, i.e. most effective, efficient (cost-effective), complete, and acceptable, and was therefore carried forward for more detailed analysis.

5 Post-Authorization Changes to the Levee Alignment

As a result of new information obtained during the PED phase, several of the authorized levee reaches have been refined to reduce costs, reduce environmental and cultural resources impacts, and improve risk and reliability. For example, Hurricane Katrina and advances in storm surge modeling revealed that narrow, sharp indentations in the alignment can lead to stacking of surge, which increases risk and makes the levee less reliable. These refinements reduced the length of the 72-mile authorized alignment by approximately 11 miles, however, post-Katrina surge modeling demonstrated that the authorized project could potentially be flanked at either end. The alignment had to be extended 16 miles to the west and 21 miles to the east to complete the system. The result of these alignment modifications and extensions resulted in a 98-mile levee project as shown in Attachment 1.

5.1 Modifications to the Authorized Alignment

The following sections describe each of the post-authorization levee reach modifications starting with modifications to the reaches that were part of the authorized project (A, G, H, J, and L). No changes were made to Reaches B, E, F, I, or K.

5.1.1 Reach A

In October 2009, the USACE evaluated four alignment options for Reach A as follows:

- The 12-mile **A1** alignment is Reach A from the authorized project alignment. The authorized alignment follows the development line along Bayou Du Large.
- The 14-mile **A1A** alignment is a slight variation on the authorized (A1) alignment. A1A generally follows the A1 Alignment with an additional 2 miles of levee around an agricultural area, which is located along a natural ridge and has the potential for future development.
- The 10-mile **A2** alignment is located west of the authorized (A1) alignment and was considered because some landowners wanted more of their farmland inside the levee. The A2 alignment shortened the authorized (A1) alignment by 2 miles and reduced marsh and bottomland hardwood impacts.
- The 9-mile **A3** alignment is a compromise between A1 and A2. A3 is the shortest alignment, has the least marsh impacts, and bottomland hardwood impacts similar to A2.

Each alternative includes two 125-foot floodgates, one 56-foot sector gate, and 6-ft by 6-ft box culverts at four locations, except for the A2 Alignment which has only two box culvert locations also has three tainter gates associated with the sector gate. Subsequent to the analysis of the four options, an even more cost effective alignment was identified which is labeled “Current Alignment” in figure 5-1.

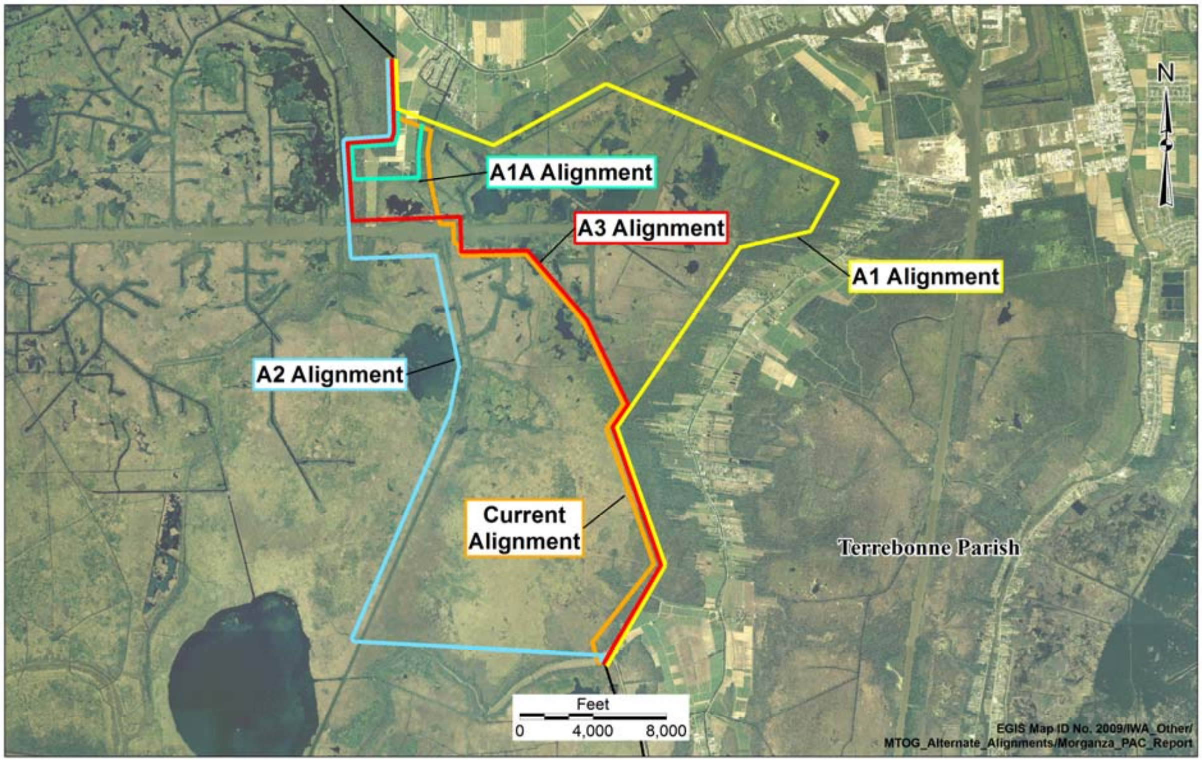

Figure 5-1. Levee Reach A Alignment Options

Environmental impacts were evaluated based on the amount of direct impacts to both marsh and bottomland hardwoods (wet and dry) and the approximate cost of mitigation as shown in table 5-1. Both Options A2 and A3 have the potential to impound more wetlands than Option A1, but box culverts are designed to reduce any potential indirect impacts. As compared to the authorized alignment (A1), the A3 alignment has more acres of bottomland hardwood (dry) impacts, but less bottomland hardwood (wet) impacts and marsh impacts.

Table 5-1. Direct Environmental Impacts for Reach A Options

Levee Impacts (acres)				Approximate Mitigation Costs ($ Millions)			
Reach	**Marsh**	**BLH Dry**	**BLH Wet**	**Marsh**	**BLH Dry**	**BLH Wet**	**Total**
A1	312	33	168	$25	$7	$19	$51
A1A	312	68	222	$25	$15	$25	$65
A2	306	56	62	$25	$12	$7	$44
A3	256	60	67	$21	$13	$7	$41

BLH = bottomland hardwood

The estimated project cost was compared for each alternative alignment as shown in table 5-2. Cost estimate includes the cost of construction, real estate, and mitigation. Cost estimates assume levees are constructed from hauled-in material from off-site borrow.

Table 5-2. Cost Estimates for Reach A Options

Reach A Options	Estimated Total Cost ($ Millions)
A1	$767
A1 including A1A	$870
A2	$680
A3	$626

Originally, Option A3 was selected because it was the most cost effective of the four alignment options. The alignment was later modified to exclude the agricultural area with the potential for future development (see area protected by Option A1A in figure 5-1). The alignment designated as "Current Alignment" in figure 5-1 is the Reach A alignment carried forward into the Morganza to the Gulf PAC levee alignment.

5.1.2 Reach G

Five alignment options for Reach G were evaluated as shown in figure 5-2 (ARCADIS, 2011). The options included the authorized alignment from the 2002 feasibility report, an alignment developed during the PED phase, and three other alignments developed for the PAC report as follows:

- **Feasibility** alignment (7.5 miles) – Includes one road crossing and two drainage structures.
- **PED** alignment (5.3 miles) – Includes one road crossing, a 30-ft stop log, and two drainage structures.
- **PAC 1** alignment (4.6 miles) – Includes one road crossing, a 30-ft stop log, and two drainage structures.
- **PAC 2** alignment (4.3 miles) – Includes one road crossing, a 30-ft stop log, and three drainage structures.
- **PAC 3** alignment (4.9 miles) – Includes one road crossing and two drainage structures.

The PED alignment reduced the authorized (feasibility) alignment costs by shortening the alignment and reducing wetland impacts by crossing open water. The remaining PAC alternatives were attempts to optimize the alignment to achieve the most cost-effective number of structures balanced with the shortest alignment and least environmental impacts.

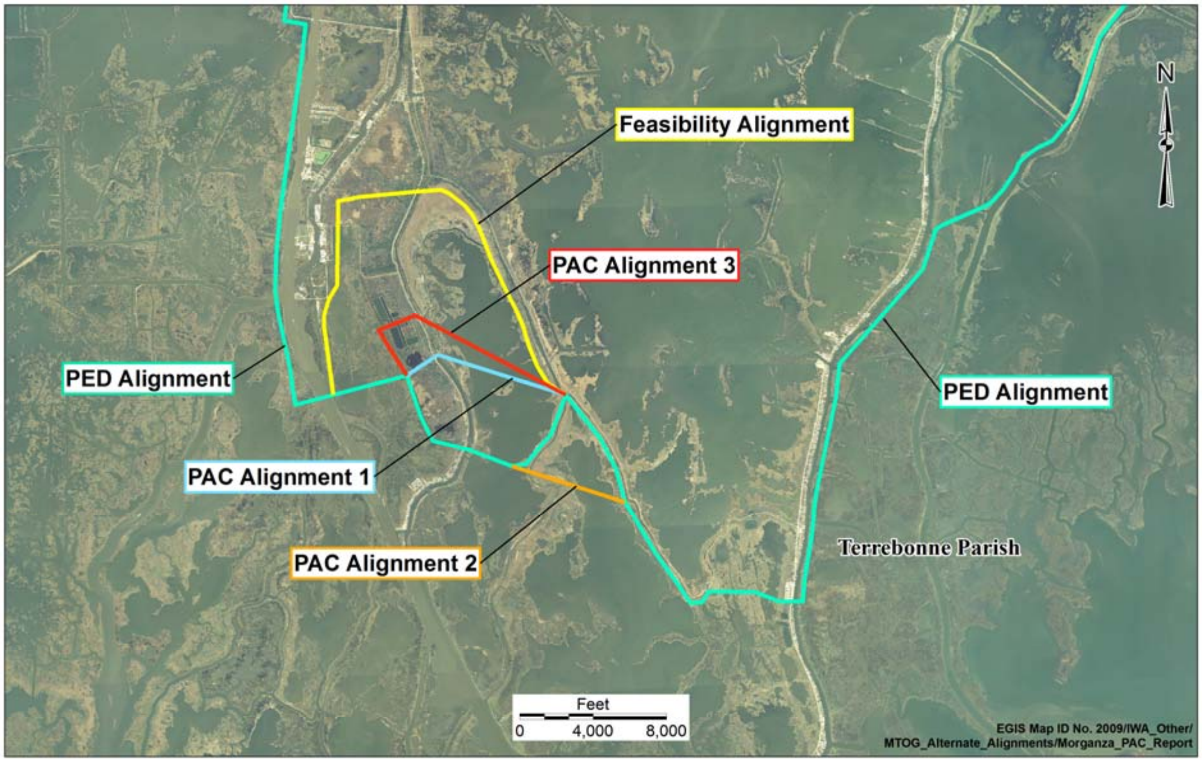

Figure 5-2. Levee Reach G Alignment Options

Environmental impacts were evaluated based on the amount of direct impacts to both marsh and bottomland hardwoods (wet and dry) due to the levee placement and the borrow pits as shown in table 5-3. Cost for the mitigation was based on a ratio, not on habitat value.

Table 5-3. Direct Environmental Impacts for Reach G Options

Reach G Options	Levee Impact (Acres)			Borrow Impact (Acres)			Total Impact (Acres)			Total Mitigation Cost ($ Millions)
	Marsh	BLH Dry	BLH Wet	Marsh	BLH Dry	BLH Wet	Marsh	BLH Dry	BLH Wet	
Feasibility	336	0	31	143	0	2	479	0	32	$42
PED	238	0	5	30	0	0	268	0	5	$22
PAC1	171	0	4	73	0	0	244	0	4	$20
PAC2	178	0	0	33	0	0	211	0	0	$17
PAC3	177	0	<1	56	0	0	233	0	<1	$19

BLH = bottomland hardwood

The estimated project cost was compared for each alternative alignment as shown in table 5-4. Cost estimates include the cost of construction, real estate, and mitigation.

Table 5-4. Cost comparison for Reach G Alignment Options

Reach G Options	Estimated Total Cost
Feasibility	$581
PED	$445
PAC 1	$407
PAC 2	$400
PAC 3	$410

The feasibility alignment was screened out because it has the highest cost, highest direct impacts, and two known cultural sites within the alignment. The PAC2 option was selected as the preferred alternative because it is the most cost effective alternative. The PAC2 option presents a tradeoff between direct and potential indirect impacts. Of all the options, the PAC2 option would have the least direct wetland impacts, but would enclose the largest amount of marsh and open water. The National Marine Fisheries Service (NMFS) and the rest of the Habitat Evaluation Team were initially concerned about the potential for indirect impacts to marsh and fishery access to wetlands and Essential Fish Habitat on the protected side; however, those concerns have been reduced by demonstrating minimal indirect impacts through systemwide modeling of environmental control structures.

5.1.3 Reach H, Segments 2 and 3 (H-2/H-3)

In 2005, the TLCD performed an alternative alignments analysis on Reach H, Segments 2 and 3 (Shaw, 2005). Agency representatives from USACE, U.S. Fish and Wildlife Service (USFWS), and NMFS had input on the alternative analysis, which considered engineering feasibility, environmental impacts, and construction costs. The following four alignments were evaluated (see figure 5-3):

- The Existing Alignment from the 2002 feasibility report, which follows the natural ridge.
- A Set Back Alignment, which moves the levee alignment out away from the ridge.
- An Existing Alignment Cross Over, which follows the Existing Alignment (see first bullet) from the south, but then crosses over to the northeast to join Reach I, eliminating the need to improve the Bush Canal levee and associated pump station in Reach I.
- A Set Back Alignment Cross Over, which follows the Set Back Alignment (see second bullet) from the south, but then crosses over to the northeast to join Reach I, eliminating the need to improve the Bush Canal levee and associated pump station in Reach I.

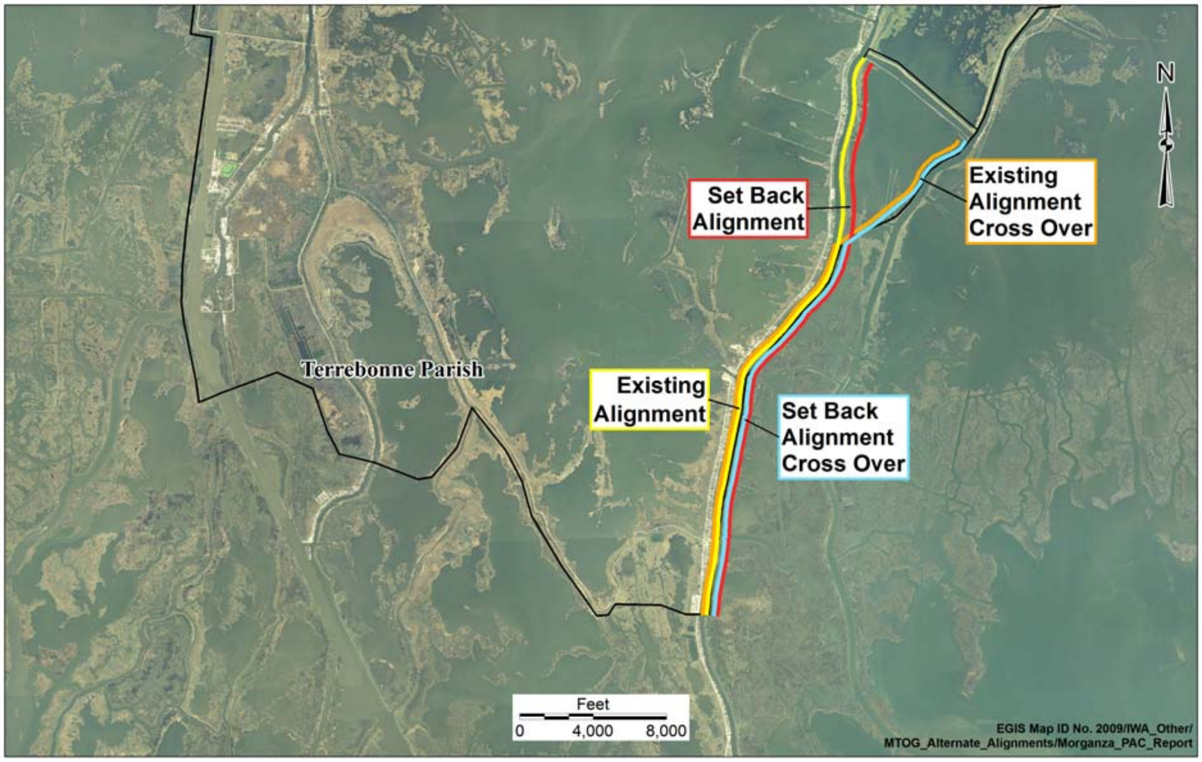

Figure 5-3. Levee Reach H Alignment Options

Additional alternatives were evaluated by combining the four alignments with different borrow assumptions (i.e., adjacent borrow, haul-in borrow, etc.). Adjacent borrow was found to be the most cost effective method. Table 5-5 shows a comparison of the four alignment alternatives assuming adjacent borrow.

Table 5-5. Estimated Costs and Direct Impacts for Reach H Options

Reach H Options	Total Impacts (acres)*	Estimated Costs ($ Millions)				
		Construct-ion Cost	Mitigation Cost	Total Cost	Bush Canal Savings	Total with Bush Canal Savings
Existing Alignment	368	$13	$7	$20	$0	$20
Set Back Alignment	453	$16	$9	$25	$0	$25
Existing Alignment Cross Over	291	$14	$5	$19	$2	$17
Set Back Alignment Cross Over	447	$15	$9	$24	$2	$22

*Includes ridge, marsh, spoil bank, and marsh impoundment.

Total costs of alternatives, taking Bush Canal savings into consideration, ranged from approximately $17 million to $72 million (an alternative with offsite borrow not shown in table 5-5). The Existing Alignment Cross Over alternative was selected as the new alignment since it had the lowest total cost of all the alternatives, either with or without the Bush Canal savings, of approximately $17 million or $19 million, respectively.

Both economically and environmentally it made sense to move the alignment to its current location. This decision was confirmed during the USACE Section 10/404 permit and State of Louisiana Coastal Use Permit evaluations. The TLCD was ultimately granted a Department of the Army permit for reaches H-2 and H-3 in November 2008.

5.1.4 Reach J, Segment 2 (J-2)

In 2004, the TLCD, in cooperation with the USACE, evaluated two alternatives for Reach J, Segment 2 as shown in figure 5-4 (GSE, 2005). In the cost projections prepared for the 2002 feasibility report, the proposed hurricane levee (J-2 Northern) was assumed to be located on natural levee soil landforms consisting of moderately strong to strong clays. An analysis of geotechnical and historic data along the existing Montegut Forced Drainage Levee system, however, indicated that as much as 70 percent of the J-2 Northern alignment, which lies outside (flood side) of the existing forced drainage levee alignment, would be placed on landforms consisting of relatively deep peat layers, overlying weak clay deposits. The unanticipated soil conditions led to an increase in projected costs associated with the planned alignment (J-2 Northern).

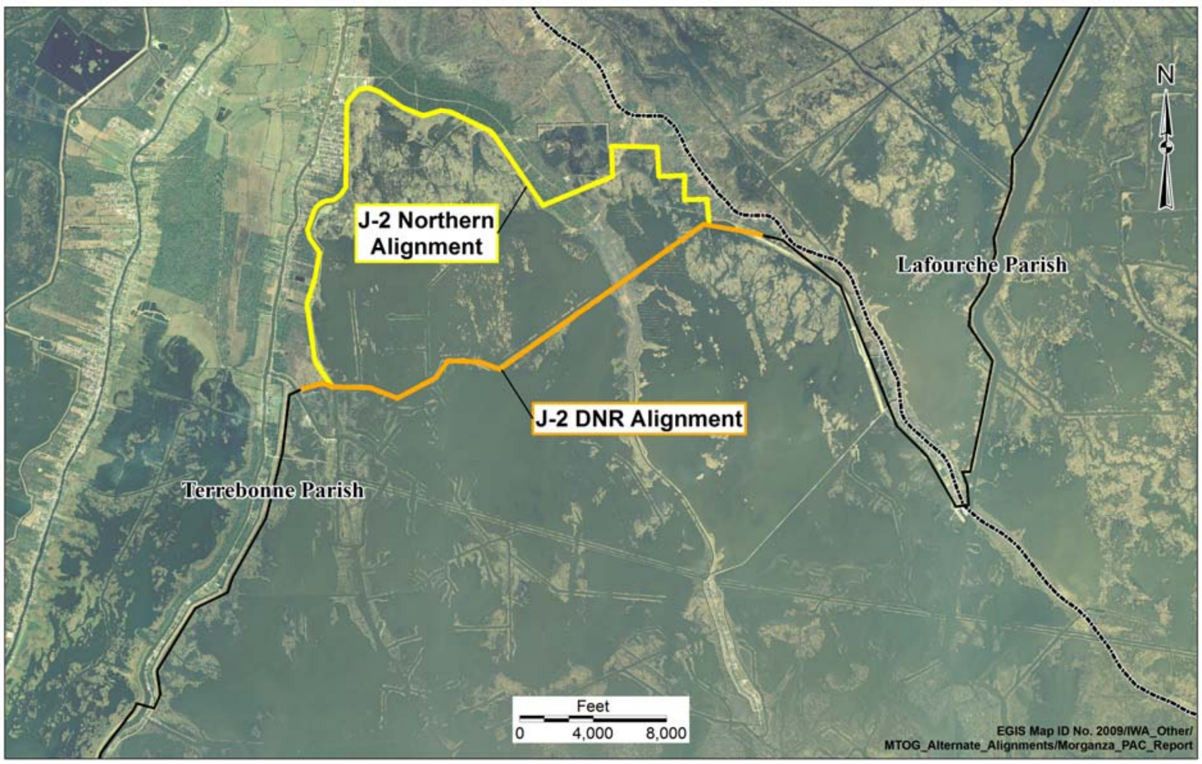

Figure 5-4. Levee Reach J-2 Alignment Options

As an alternative to the J-2 Northern alignment, the team evaluated an alignment following the existing Department of Natural Resources (DNR) marsh restoration levee. Table 5-6 provides a comparison of the J-2 Northern alignment and the alternative J-2 DNR alignment. The J-2 DNR alignment shortens the total levee length from the Humble Canal to the western terminus of Segment J-1 from approximately 9.5 to 5.3 miles. The J-2 DNR levee would reduce direct wetland impacts from 345 acres to 83 acres. The J-2 DNR levee alignment would also reduce all bottomland hardwood impacts to zero. Indirect impacts would be minimal because of the existing levees and structures associated with the J-2 DNR marsh management system.

Table 5-6. Comparison of Reach J-2 Alignment Options

Item	J-2 Northern Alignment	J-2 DNR Alignment
Levee Length	9.5 miles	5.3 miles
Environmental Control Structures	1	3
Pipeline crossings	4	3
Footprint Area	556 acres	323 acres*
Wetlands Impacted	345 acres	83 acres
Additional Wetlands Restoration Area	0 acres	1,035 acres
Total Cost	$32 Million	$18 Million

*Within the 323-acre footprint, 138 acres are existing levee and borrow canal, so the DNR Alternate Alignment only adds 185 acres to the new footprint.

The J-2 DNR alternative was selected because it has less environmental impact and is less expensive than the original J-2 Northern alignment. The cost savings associated with the construction of the J-2 DNR alignment versus the construction of the original J-2 Northern alignment was estimated at over $14 million. The reduced cost for the construction of the more southern J-2 DNR alignment is primarily due to the fact that most of this levee would be constructed on existing levees. Approximately 20 percent of the alignment would be on stable levees and would not require reinforced geotechnical fabric or a sand base. Those portions of the new levee constructed on the J-2 DNR levee sections would require less embankment fill, as well as less sand fill than required in the authorized alignment.

5.1.5 Reach L

In October 2009, the USACE evaluated three alignment options for Reach L (see figure 5-5):

- **L1** is the authorized alignment, which consists of 5.4 miles of levee and two box culvert locations.
- The **L2 alignment** was developed during PED discussions as having potential to reduce Larose to Golden Meadow upgrade costs. L2 consists of 6.1 miles of levee and two box culvert locations.
- **The L3** alignment was requested by stakeholders, because it is similar to L2 in length and impacts and has the added economic benefit of including Apache Mineral property inside the alignment and further reducing Larose to Golden Meadow improvement costs. L3 consists of 6.1 miles of levee and one box culvert location.

Each alternative has one 56-ft sector gate with three 46-ft tainter gates and 6-ft by 6-ft box culverts at various locations.

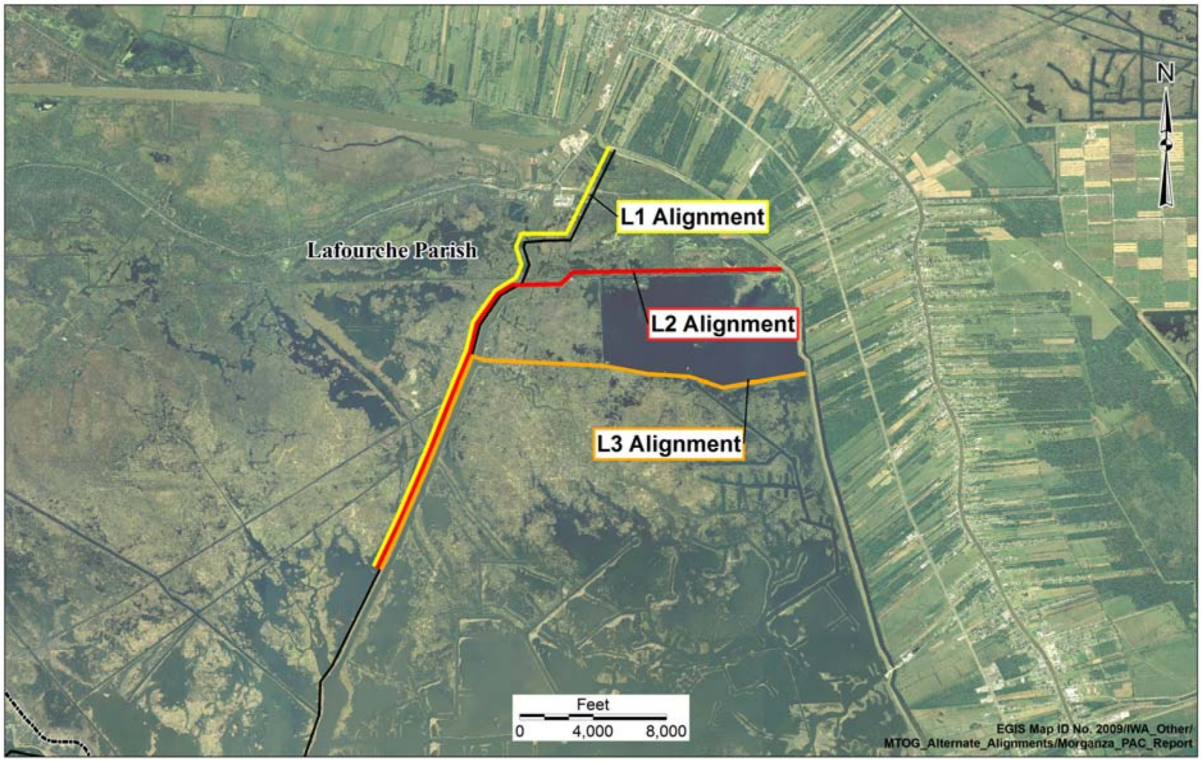

Figure 5-5. Levee Reach L Alignment Options

Environmental impacts were evaluated based on the amount of direct and indirect impacts to both marsh and bottomland hardwoods (wet and dry) and the approximate cost of mitigation as shown in table 5-7.

Table 5-7. Direct Environmental Impacts for Reach L Options

Levee Impacts					Approximate Mitigation Costs ($ Millions)			
Reach L Options	Levee length (mile)	Marsh* (acres)	BLH dry (acres)	BLH wet (acres)	Marsh#	BLH Dry	BLH Wet	Total
L1	5.4	209	19	0	$17	$4	$0	$21
L2	6.1	240	0	29	$19	$0	$3	$22
L3	6.1	163	0	0	$13	$0	$0	$13

BLH = bottomland hardwood.

Option L3 assumes placement of the alignment inside existing levee, not south of it. With Option L2 there is a potential to enclose approximately 1,320 acres of wetlands more than L1. With Option L3 there is a potential to enclose approximately 1,970 acres of wetlands more than the L1 alignment. The estimated project cost was compared for each alternative alignment as shown in table 5-8.

Cost estimates include the cost of construction, real estate, and mitigation. All earthen levees would be constructed of hauled-in material from off-site borrow. Although Reach L3 is longer than the authorized alignment (L1), it would reduce the length of the existing Larose to Golden Meadow levee that would need to be raised, resulting in an overall lower net cost.

Table 5-8. Cost Estimates for Reach L Options

Reach L Options	Estimated Costs ($ Millions)		
	Total Cost	Larose Savings*	Net Costs
L1	$561	$0	$561
L2	$633	$207	$427
L3	$615	$297	$319

*Savings for portions of Larose to Golden Meadow levees that would not need to be raised. These savings may or may not be realized pending the outcome of the Larose PAC, which is not yet complete. Additional discussions on the Larose to Golden Meadow project are included in sections 5.2.2 and 6.5.2.

Option L3 was selected because it is the most cost effective alternative. As compared to the authorized alignment, the new alignment has less bottomland hardwood (dry) impacts and less marsh impacts. Option L3 encloses approximately 2,000 additional acres compared to the authorized alignment (L1), but box culverts are designed to reduce any potential indirect impacts.

5.2 Extensions to the Authorized Alignment

Based on relative sea level rise projections and higher post-Katrina surge levels, the authorized alignment had to be extended to the west and to the east in order to complete the Morganza to the Gulf project. Both PAC alternatives follow the same 98-mile levee alignment but at different levels of risk reduction (1% and 3% AEP).

5.2.1 <u>Western Levee Extension (Barrier Reach)</u>

Two alternative alignments were evaluated as part of a screening-level analysis—a "Barrier Alignment" and a "Northern Alignment." Both alignments originate at Minor's Canal. The alternatives are as follows:

- The Barrier Alignment is 15.4 miles and generally follows the edge of development along the south side of the Black Bayou ridge (LA 182/Old US 90).
- The Northern Alignment is 15.6 miles and runs west along Bayou Black Ridge for approximately 2 miles, then turns north and follows Savane Road (Parish Road 23) up to the Little Bayou Black Ridge. The alignment then follows the southern development boundary along Bull Run Road (Chacahoula ridge) northwest until it ties in to Highway 90.

As shown in figure 5-6, the Barrier Alignment incorporates additional assets and people along the Bayou Black ridge that are not included within the Northern alignment. Table 5-9 includes the number of people and the value of equivalent annual benefits based on the 2009 inventory of structures located between the Barrier and Northern alignments. Table 5-9 also provides the estimated cost for each alignment as well as the cost difference between the two alignments. The Northern Alignment has not been designed to full feasibility level, but would have the same levee width as the Barrier, but at a slightly lower elevation. The Northern Alignment would also require fewer structures than the Barrier alignment.

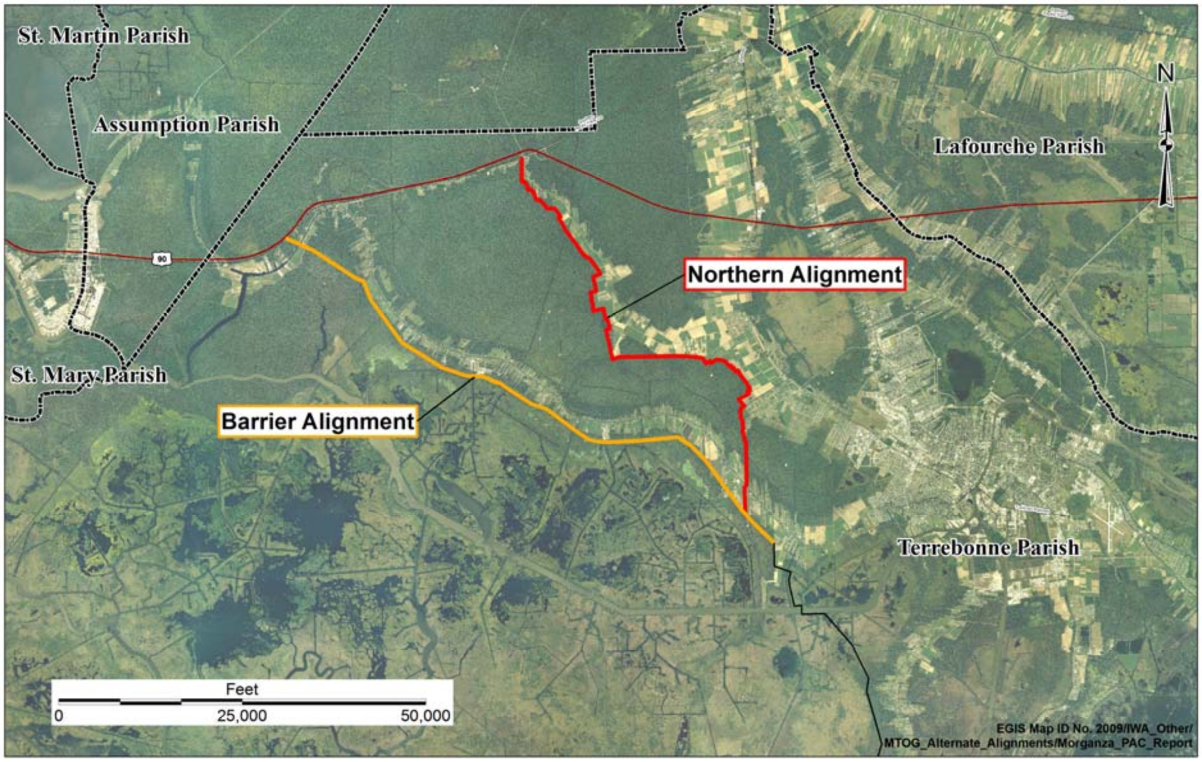

Figure 5-6. Barrier and Northern Levee Alignment Options

Table 5-9. Incremental Costs and Benefits between Northern and Barrier Levee Alignments

Options	Estimated Cost ($millions)	Incremental Total Benefits ($millions)	Incremental Equivalent Annual Benefits ($millions)	Incremental Number of People
Northern Alignment	$710	N/A	N/A	N/A
Barrier Alignment	$965.2	$603.3	$28.1	3,400
Increment Between Barrier and Northern	$255.2	$603.3	$28.1	3,400

Note: Economic benefits calculated based on 2035 to 2085 period of analysis. Number of people estimated based on 2009 structure inventory. Construction cost does not include mitigation costs; see table below.

Table 5-10. Direct Wetland Impacts for Northern and Barrier Levee Alignment Options

Option	Total Footprint Acres	Marsh Acres	Swamp Acres	Other Acres (uplands, open water, etc.)	Estimated Mitigation Cost ($millions)
Barrier	691	86	518	87	$64.4
Northern	634	0	464	170	$51.5

Although the Barrier Alignment has a slightly larger footprint and impacts more wetlands as shown in table 5-10 and has a higher cost than the Northern Alignment, the Barrier was selected to complete the Morganza to the Gulf levee alignment because it reduces risk to 3,400 more people than the Northern Alignment. As well as leaving a large number of people unprotected, the Northern alignment could induce damages on Bayou Black areas to the south and west of the alignment.

5.2.2 Eastern Levee Extensions (Larose C-North and Lockport to Larose Reaches)

The eastern extent of the authorized Morganza to the Gulf project (Reach L) ties into the northwestern portion of the existing Larose to Golden Meadow project. The Larose to Golden Meadow ring levee system extends from the town of Larose, LA to a point 2 miles south of Golden Meadow, LA and provides hurricane and storm damage reduction to roughly 25,000 people living on both sides of Bayou Lafourche. Surge modeling for the 2002 feasibility report did not show flanking of the Morganza project from the east across Bayou Lafourche, but new modeling shows that the Morganza project could be flanked if the existing Larose to Golden Meadow levee elevations are not brought up to Morganza-compatible design standards.

The Larose to Golden Meadow project is currently undergoing a PAC analysis similar to the Morganza to the Gulf PAC analysis and future levee elevations for the Larose ring levee system have not yet been determined, however, none of the Larose PAC alternatives include raising the Larose levees to the 1% AEP risk reduction level. The highest level of risk reduction being considered is a 2% AEP plan. In the event that Congress does not re-authorize and fund improvements to the Larose to Golden Meadow ring levee to bring it up to a level of risk reduction comparable to the Morganza project, a 7-mile levee following a portion of the Larose to Golden Meadow levee alignment has been added to the Morganza PAC project (labeled as C-North and GIWW reaches on figure 5-7 but collectively referred to as "Larose C-North Reach" throughout the rest of this report).

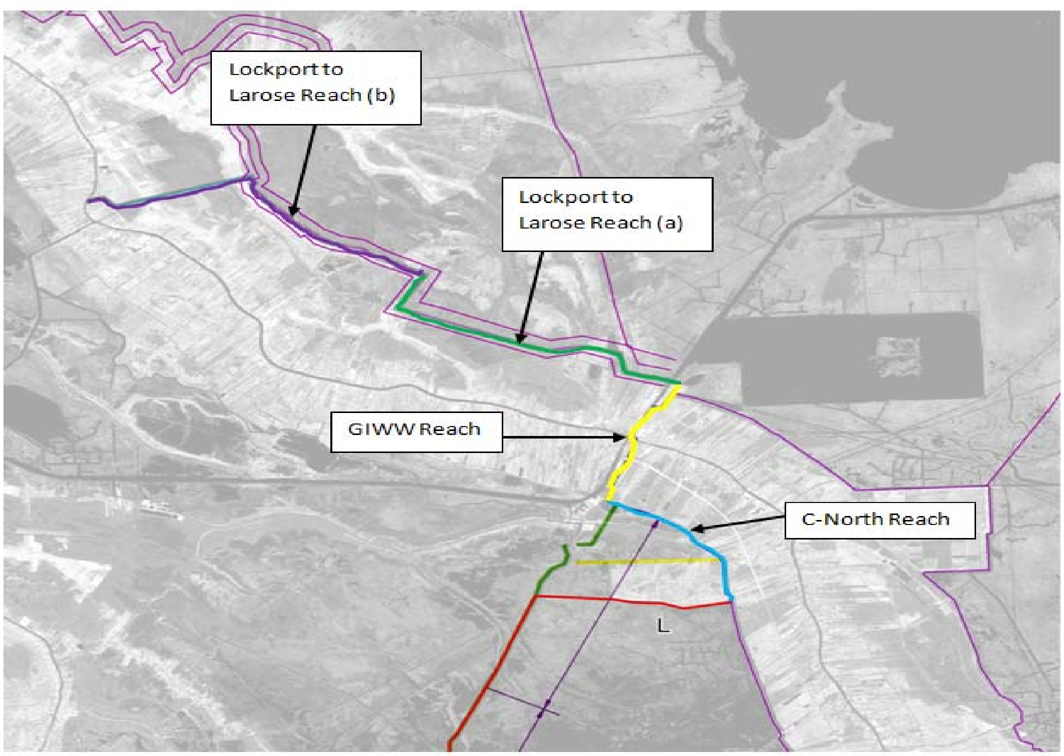

Figure 5-7. Barrier and Northern Levee Hydraulic Reaches

To complete the Morganza to the Gulf system, the alignment had to be further extended from the Larose C-North Reach up to Lockport, LA (see figure 5-7). The Lockport to Larose Reach follows an alignment formerly proposed under the Donaldsonville to the Gulf feasibility study. This levee reach was included because the Bayou Lafourche ridge, which is approximately 6 ft in elevation, provides some protection from surges coming up from the Barataria Basin, but could be overtopped in the future with relative sea level rise.

6 Evaluation and Comparison of Alternatives

In accordance with the WRDA 2007 implementation guidance, the PAC report compares the following two alternatives in detail:

- **<u>3% AEP Alternative (pre-Katrina 100-yr alternative)</u>** - The 3% AEP alternative is a hurricane levee system that provides risk reduction for water levels that have a three percent probability of occurring each year. This alternative is generally based on the pre-Katrina authorized project, but is modified to be consistent with post-Katrina design standards. Levee elevations for future conditions (year 2085) range from +13 to +20 ft NAVD88. Structure elevations range from +15 to +25 ft NAVD88.
- **<u>1% AEP Alternative (post-Katrina 100-yr alternative)</u>** - The 1% AEP alternative is a hurricane levee system that provides risk reduction for water levels that have a 1 percent probability of occurring each year. This alternative has the same intended level of risk reduction as the pre-Katrina authorized project, but is modified to be consistent with post-Katrina design standards. Levee elevations for future conditions (year 2085) range from +19.5 to +26.5 ft NAVD88. Structure elevations range from +17.5 to +33 ft NAVD88.

The 3% and 1% AEP alternatives both follow the same 98-mile levee alignment previously described in section 5, Post-Authorization Changes to the Levee Alignment.

6.1 Comparison of 3% and 1% AEP Levee and Floodgate Designs

The same storms used to model the without-project condition were simulated to estimate water levels and waves along the proposed levee project alignment. Outputs included surge and wave information at 320 locations along the proposed levee alignment. Table 6-1 summarizes the approximate surge and wave elevations used to design levee elevations by reach.

Table 6-1. Predicted With-Project Surge and Waves from 2035 (Base) to 2085 (Future)

Levee Reach(es)	Surge Still Water Elevations (ft NAVD88)		Wave Heights (ft NAVD88)	
	3% AEP	1% AEP	3% AEP	1% AEP
Barrier Reach and Reach A North of the GIWW	7 to 10	10 to 14	2 to 3	3 to 5
Reach A South of the GIWW and Reach B	9 to 11	12 to 14	2 to 3	4 to 5
Reaches E and F	11 to 12	15 to 17	2	4 to 5
Reaches G	11 to 12	15 to 16	5	7
Reaches H, I, and J	12 to 14	16 to 18	5 to 6	7 to 8
Reaches K and L	12 to 13	16 to 18	3 to 4	5 to 6
Larose C-North Reach	7 to 12	9 to 16	2 to 3	2 to 3
Lockport to Larose	6 to 9	8 to 10	2 to 4	3 to 5

Note: Values are rounded to the nearest foot. More detailed information can be found in the Engineering Appendix. Values are for the Intermediate RSLR scenario. See section 6.9 for a discussion on the Low and High RSLR scenarios.

Levee dimensions are shown in table 6-2. Levee crown elevations were determined by ensuring that the elevation equaled or exceeded the required hydraulic design elevation given the Intermediate RSLR scenario at any given point in time between the base (2035) and future (2085) years. The design elevations vary by levee reach because of surge and wave differences due to storm path, wind speeds and direction, etc. The variation in design elevations is required to provide the same level of risk reduction along the entire length of the project. The 1% AEP alternative design elevations are generally 5.5 to 8 ft higher than the corresponding 3% AEP design elevations.

Table 6-2. Comparison of Levee Reach Dimensions for the 3% and 1% AEP Alternatives

Levee Reach	Length (miles)	Authorized Elevation (NGVD)	Range of Levee Design Elevations Between 2035 and 2085 (ft NAVD88)		Maximum Levee Toe to Toe Width (ft)	
			3% AEP Alternative	1% AEP Alternative	3% AEP	1% AEP
Barrier	15.7	N/A	10 to 13	15.5 to 20	174	329
A	8.2	10.5	10 to 13	15.5 to 20.5	174	329
B	5.1	12	11.5 to 13.5	17.5 to 20.5	355	610
E	4.4	14	14.5 to 15.5	21.5 to 23.5	440	725
F	4.1	14	14.5 to 15.5	22 to 23.5	270	490
G	5.8	15	16.5 to 17.5	22.5 to 24	270	550
H	7.9	15 to 16	18.5 to 20	24 to 26.5	330	500
I	5.7	14 to 15	18.5 to 20	24 to 26.5	319	570
J	9.3	14	18.5 to 20	24 to 26.5	337	660
K	5.1	12 to 14	16.5 to 17.5	22.5 to 25.5	400	635
L	5.9	10 to 11	16.5 to 17.5	22.5 to 25.5	400	635
Larose C-North	7.0	N/A	13.5 to 15.5	18 to 20.5	252	467
Lockport to Larose	12.6	N/A	8.5 to 12	10.5 to 15	282	282

Note the different datum for the authorized (NGVD) and current (NAVD88) elevations. The change in elevation due to datum differences varies by location, and is around 0.5 to 1.5 ft.

Table 6-3 lists floodgates along the levee alignment from west to east; the floodgate dimensions refer to the primary gate width. Structure elevations are higher than levees within the same reach because structure designs include 2 ft of additional height (structural superiority) to accommodate potentially higher RSLR and other uncertainties.

Hundreds of detailed engineering drawings showing phased construction site plans, cross sections, and foundation plans were developed for the PAC report. For most structural features, designs were prepared for a limited number of structures and the remainders were pro-rated.

Table 6-3. Floodgate Elevations for the 3% and 1% AEP Alternatives

Reach	Waterway	Structure Design Size/Type (subject to change during detailed design)	3% AEP Design Elevation (ft)	1% AEP Design Elevation (ft)
Barrier	Bayou Black	56-ft sector gate	15.0	22.0
	Shell Canal West	30-ft stop log gate	16.0	23.5
	Shell Canal East	56-ft sector gate	16.0	23.5
	Elliot Jones Canal	20-ft stop-log gate	16.0	23.5
	Humphreys Canal	20-ft stop-log gate	16.0	23.5
A (north of GIWW)	Minor's Canal	56-ft sector gate	16.0	23.0
A	GIWW West (at Houma)	125-ft sector gate	16.0	23.0
B	Marmande Canal	30-ft stop-log gate	16.5	23.0
	Falgout Canal	56-ft sector gate	16.5	23.0
E-2	Bayou Du Large	56-ft sector gate	18.0	25.5
F-1	Bayou Grand Caillou	56-ft sector gate	18.0	25.5
G-1	HNC	250-ft sector gate and lock	22.5	30.5
G-2	Four Point Bayou	30-ft stop-log gate	22.5	30.0
H-1	Bayou Petit Caillou	56-ft sector gate	22.5	30.5
H-2	Placid Canal	56-ft sector gate	24.0	31.5
H-3	Bush Canal	56-ft sector gate	25.0	33.0
I-1	Bayou Terrebonne	56-ft sector gate	25.0	33.0
I-3	Humble Canal	56-ft sector gate	25.0	33.0
J-3	Bayou Pointe aux Chenes	56-ft sector gate	25.0	33.0
L	Grand Bayou	56-ft sector gate	21.0	29.5
Larose C-North	Bayou Lafourche	56-ft sector gate	14.0	17.0
	GIWW East (at Larose)	125-ft sector gate	17.0	21.5

6.2 Multi-Lift Levee Construction

Levees were placed as close as practical to the natural ridges along existing or former bayous to take advantage of the stronger foundation conditions and reduce the probability of failure during and after construction. Sediments that comprise the natural ridges are stronger than the sediments in the lower surrounding areas, especially sediments that are in open water environments. Levee construction on top of the marsh sediments will be challenging from a stability and settlement viewpoint, especially for levee heights exceeding 15 ft. Multi-lift construction will help achieve the desired crown elevations. Geotextile reinforcement, berms, and flat berm slopes were used to achieve stable levees. Settlement analyses are an important part of the study due to the added construction cost associated with settlement during and after construction.

Generally, the approach for multi-lift levee construction consists of an initial preload lift to an elevation between +12 to +14 ft NAVD88 to provide a good base and working surface. Prior to construction on the second lift (first enlargement), the initial preload lift is expected to settle to approximately +10 ft NAVD88. As part of second lift construction, the existing preload levee would be degraded to approximately +4 ft NAVD88 and reinforcing geotextile installed. To achieve levee design elevations at target years 2035 and 2085, each reach requires two or three additional lifts between approximately 2020 and 2070. Levee lift elevations at the time of construction would generally be a few feet higher than the targeted design elevations to allow for levee settlement. After construction of each levee lift is completed, the levee would be covered in grass to increase its resilience in the case of wave overtopping.

As shown in table 6-4, the 1% AEP plan requires more than twice the material for levee construction as the 3% AEP alternative plan.

Table 6-4. Material Quantities by Levee Lift and Alternative

Levee Lift	Estimated Quantities (CY)	
	3% AEP Alternative	1% AEP Alternative
1st Lift/Preload	40,596,000	43,396,000
2nd Lift/1st Enlargement	14,458,000	65,929,000
3rd Lift/2nd Enlargement	4,581,000	10,725,544
4th Lift/3rd Enlargement*	1,224,000	6,182,000
Total	60,859,000	126,233,000

*Since C-North is the only reach with a 5th Lift/4th Enlargement, those quantities have been grouped with the 4th Lift/3rd Enlargement quantities for the rest of the levee reaches. All quantities rounded to the nearest 1,000.

Figures 6-1 and 6-2 are examples of lift schedules for different levee reaches and different levels of risk reduction. Figure 6-1 shows the lift schedule for Reach A/Barrier in the 3% AEP alternative, which has the lowest elevation and requires only three lifts to achieve the final design elevation (13 ft) in 2085. Reach A/Barrier would meet the 2035 design elevation (10 ft) after the first lift. Figure 6-2 shows the lift schedule for Reach J in the 1% AEP alternative, which has the highest elevation and requires four total lifts to achieve the final design elevation (26.5 ft) in 2085. Reach J would meet the 2035 design elevation (24 ft) after two lifts.

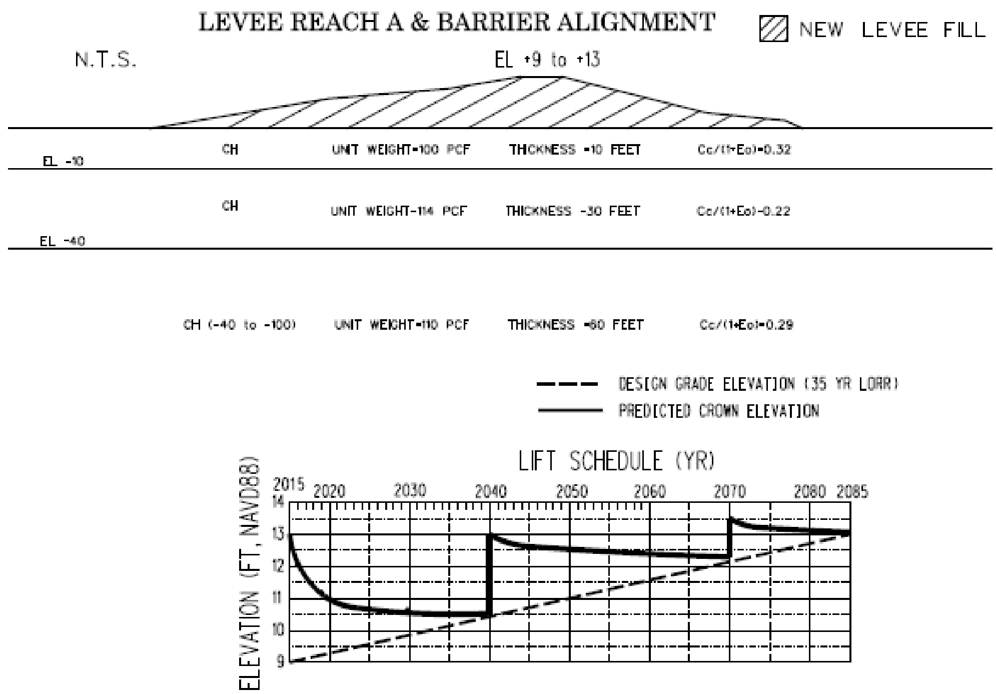

Figure 6-1. Example Lift Schedule for 3% AEP Alternative Reach A/Barrier

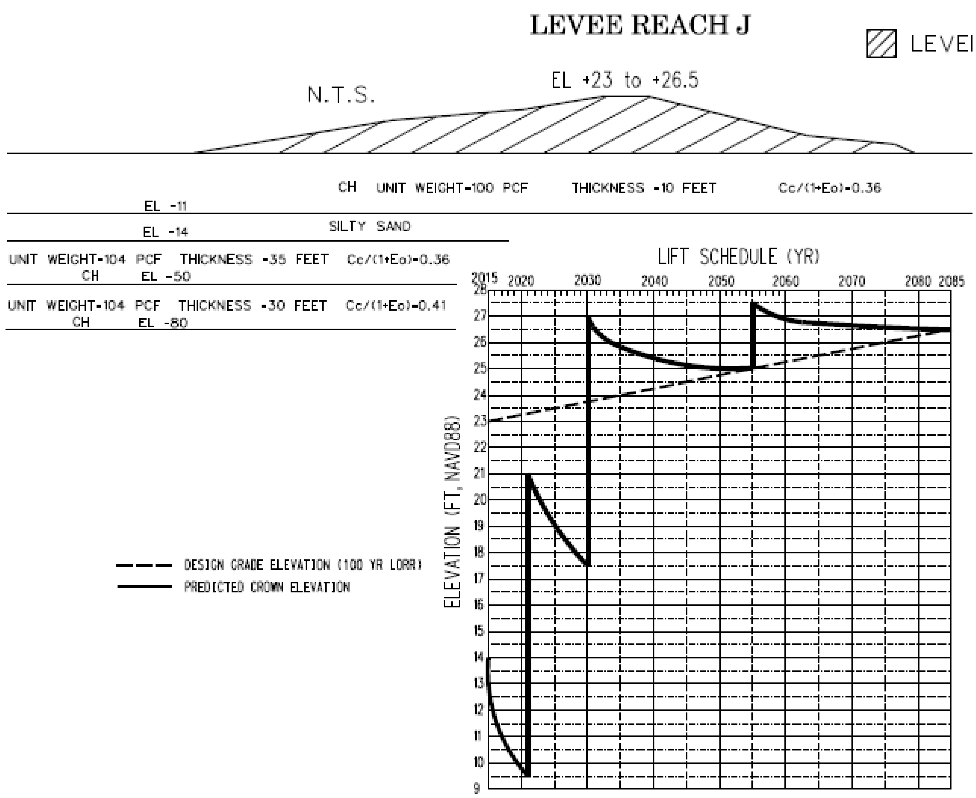

Figure 6-2. Example Lift Schedule for 1% AEP Alternative Reach E

6.3 Construction Schedule Assumptions

Preliminary construction schedules for alternatives are needed to calculate annual cost streams and benefit-cost ratios. Project benefits cannot start accruing until a “closed” risk reduction system is in place, which would require, at a minimum, all structures and first lift levees to be constructed. Assuming construction starting in 2015 and adequate funding (schedules were not constrained by potential funding levels), both alternatives would have a closed system by 2024. Based on reasonable construction durations that allow for levees to settle and compact between lifts, the alternatives could achieve their associated 3% or 1% AEP levels of risk reduction by 2035, however, as shown in table 6-5, the 3% AEP plan could achieve its base year design elevations almost 10 years sooner than the 1% AEP plan.

Table 6-5. Implementation Schedule Assumptions by Activity

Activities	Timeframe for 3% AEP	Timeframe for 1% AEP
Acquire Real Estate, Relocate Utilities, and Mitigate	2014 to 2023	2014 to 2025
Construct Lock, Floodgates, and Environmental Control Structures	2015 to 2024	2015 to 2024
Construct Levee Lifts to Achieve Base Year Elevations	2015 to 2026	2015 to 2035
Construct Levee Lifts to Achieve Future Year Elevations	2033 to 2072	2035 to 2075

The 1% AEP alternative takes longer to achieve its base year level of risk reduction, because more material is required to build the larger levee, and in some levee reaches, more than one lift is required to achieve the base year (2035) design elevations, as shown in table 6-6.

Table 6-6. Number of Levee Lifts Required to Achieve Base and Future Year Design Elevations

Reach	3% AEP Alternative		1% AEP Alternative	
	Base Year (2035)	Future Year (2085)	Base Year (2035)	Future Year (2085)
Barrier & A	1	3	2	4
B & E	2	3	3	4
F	2	4	3	4
G	2	3	3	3
H & I	2	3	3	4
J	2	4	3	4
K & L	2	3	3	4
Larose C-North	1	4	1	5
Lockport to Larose	1	2	2	3

After 2035, both alternatives would require additional levee lifts to achieve the future year (2085) design elevations because of continuing sea level rise and subsidence. The lift schedule is based on keeping the actual levee elevation at or above the design elevation between 2035 and 2085 allowing for several years of settlement after construction of each lift. The actual level of risk reduction for each alternative would vary over time depending on the construction timing.

6.4 Environmental Impacts

The major impact of the project is the loss of wetlands within the project right of way. Mitigation for wetland impacts would be through the restoration of eroded and subsided wetlands in the project area. The project would complement state and Federal coastal restoration projects by providing protection against coastal erosion and adverse effects of storm surges. A more detailed wetland impact study of direct, indirect, and cumulative environmental impacts of the alternatives is included in the RPEIS.

6.4.1 Direct Impacts

Construction of the 3% or 1% AEP alternatives would directly impact 3,213 or 4,113 wetland acres (combination of marsh, swamp, and bottomland hardwoods). Impacts of the project would slightly decrease as sea level rises because there would be less wetland acres left to be impacted at the time of construction. The direct impacts of the project on the aquatic habitat of Lake Boudreaux would be temporary. The project would directly impact a narrow band of riparian habitat along the banks of the Bayou Grand Caillou. Direct impacts can be reduced by placement of dredged material in open areas, where practicable.

6.4.2 Indirect Impacts on Hydrology and Salinity

The authorized alignment builds on existing hydrologic barriers, such as natural ridges, roadbeds, or existing levees that have been built for other purposes such as forced drainage or marsh management. Of the estimated 72 miles of levee originally proposed in the authorized alignment, approximately 15 miles would cross part of the estuaries that are currently open to estuarine exchange. Thus, the construction of the levee itself would cause very little new indirect impacts on estuarine hydrology. The proposed project includes numerous environmental water control structures to allow hydrologic exchange through the levees.

A Systemwide Model was used to determine the impacts of the project on hydrology and salinity. The validated model (McAlpin, 2009) for calendar year 2004 was modified to include three system or "plan" configurations and was used to compare the existing without-project conditions to with-project conditions. All three configurations represent operation during non-tropical storm conditions. During tropical storm conditions, all structures would be closed. A comprehensive analysis was performed on the water surface elevations, discharges, and salinity to obtain an approximate indication of the resulting behavior of the system if the proposed changes were to occur.

Structures were modeled as part of two groups: (1) floodgates on navigable waterways and (2) environmental water control structures. Structure groups were modeled in either the open or closed position. The three conditions or "plans" are described below.

Plan 1 - All structures in the open position. The purpose of modeling this condition is to determine the scale of hydrodynamic and salinity impacts of the Morganza project under everyday non-storm conditions. Plan 1 possesses minimal global salinity changes with the largest changes occurring in the marsh area south of Falgout Canal. This area is newly connected to Falgout Canal allowing for a new freshwater inflow to this area, which in turn reduces the salinity (about 3 ppt) with the largest benefit occurring during the winter months and minimal benefit occurring during the summer months. Globally, the salinity changes tend to be less than 1 ppt.

Plan 2 - All floodgates on navigable waterways in the open position and all environmental water control structures in the closed position. This condition would never occur under the current structure operation plan, but was modeled to isolate the effects of the environmental water control structures. The structure operation plan for storm surge is to leave all structures open during everyday non-storm conditions and to close them during high water levels due to storm conditions. Plan 2 has minimal global salinity changes (less than 2 ppt) with some increased salinity possible in local areas newly cutoff by the proposed levee system. Plan 2 has some areas that possess no connection to the remainder of the domain (due to closed environmental water control structures) and therefore would remain stagnant with constant water levels and salinity.

Plan 3 - All structures in the open position with the exception of the HNC structure and lock in the closed position. This condition represents operation of the HNC lock complex for salinity control and would occur whenever certain salinity criteria are met at designated monitoring stations. Plan 3 has noticeable salinity changes along the HNC. Salinity increases along the southern portion (~4 ppt) and lowered north of the HNC structure. The Falgout Canal and Lake Boudreaux areas would be freshened as the closed HNC structure forces the freshwater flow to divert along other avenues, thereby freshening the surrounding areas.

Sensitivity simulations demonstrated the importance of the two GIWW structures. Reducing the size of the western structure reduces the freshwater inflow able to enter the Morganza levee system and thereby increases the salinity in the study area. Conversely, reducing the size of the eastern GIWW at Larose structure reduces the amount of freshwater able to leave the system and therefore decreases the salinity in the study area. While navigational concerns require certain structure sizes for these two areas, those simulations exhibit the type of control the new levee system would provide operators.

Through proper management of the planned structures a number of different salinity results, both beneficial and not, can be accomplished. The results indicate that if structures are properly operated, the proposed levee system would have a minimal effect on the global salinity values.

6.5 Potential Induced Flooding

Given the modeling resolution at the time, the potential for induced flooding outside the levee was not identified in the 2002 feasibility report, however, post-Katrina surge modeling results indicate that the project could increase water levels in areas immediately outside the risk reduction system during storm events. When comparing the results of the ADCIRC runs for the without-project to the with-project conditions for existing 1% AEP water levels, the with-project water levels under a storm event are approximately 2 to 3 ft higher as shown in figures 6-3 and 6-4.

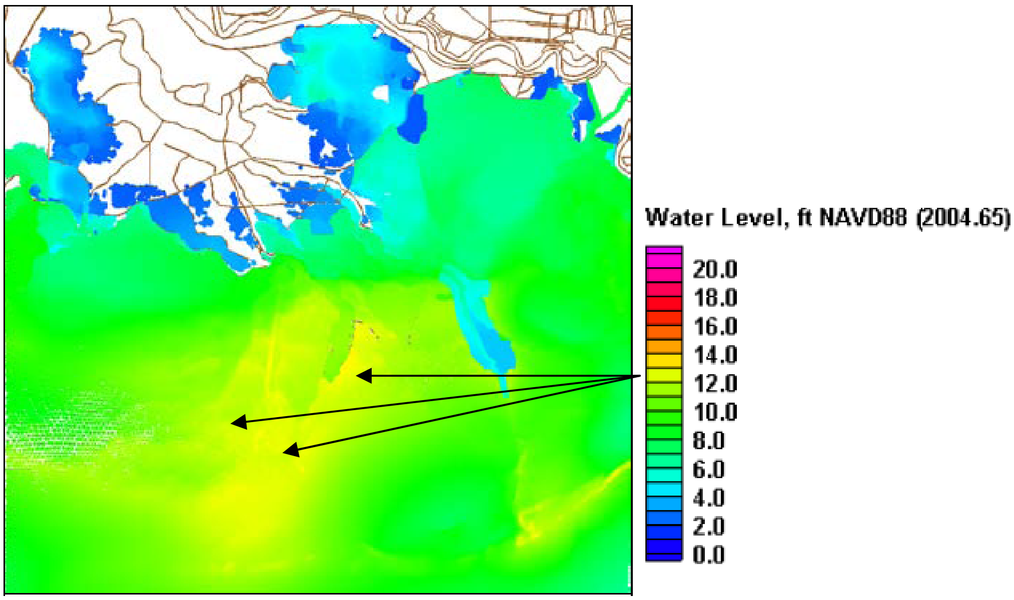

Figure 6-3. 1% AEP Existing Without-Project Water Levels

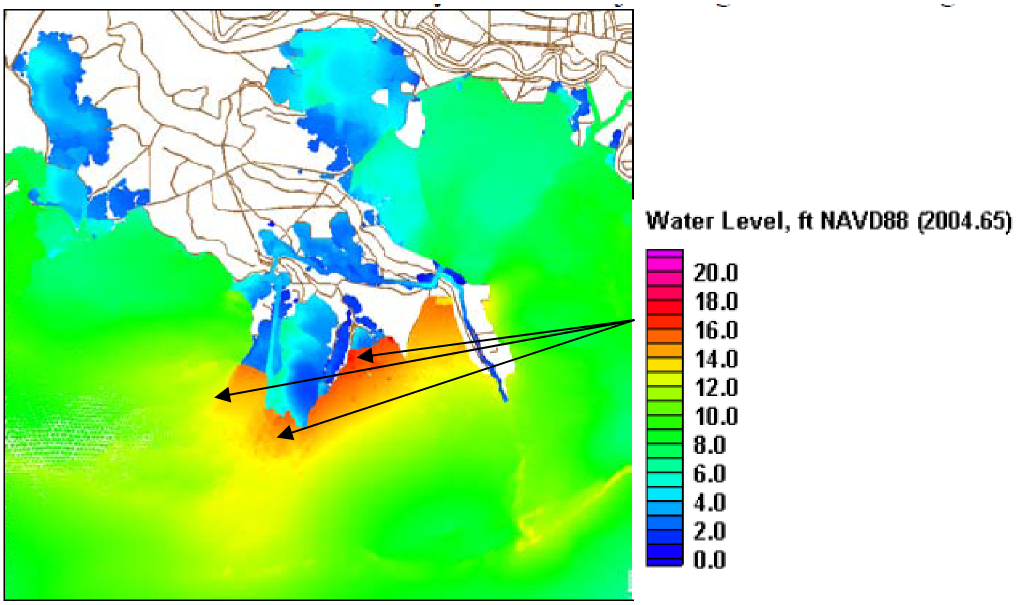

Figure 6-4. 1% AEP Existing With-Project Water Levels

6.5.1 Impacts on Structures Outside of the Risk Reduction System

Approximately 1,000 structures would remain outside of the Morganza to the Gulf risk reduction system (see red areas in figure 6-5). These areas include Isle de Jean Charles and parts of Bayou Du Large and Bayou Grand Caillou. Although areas outside the levee system would already receive damages under the without-project conditions, the alternatives could increase damages during some events.

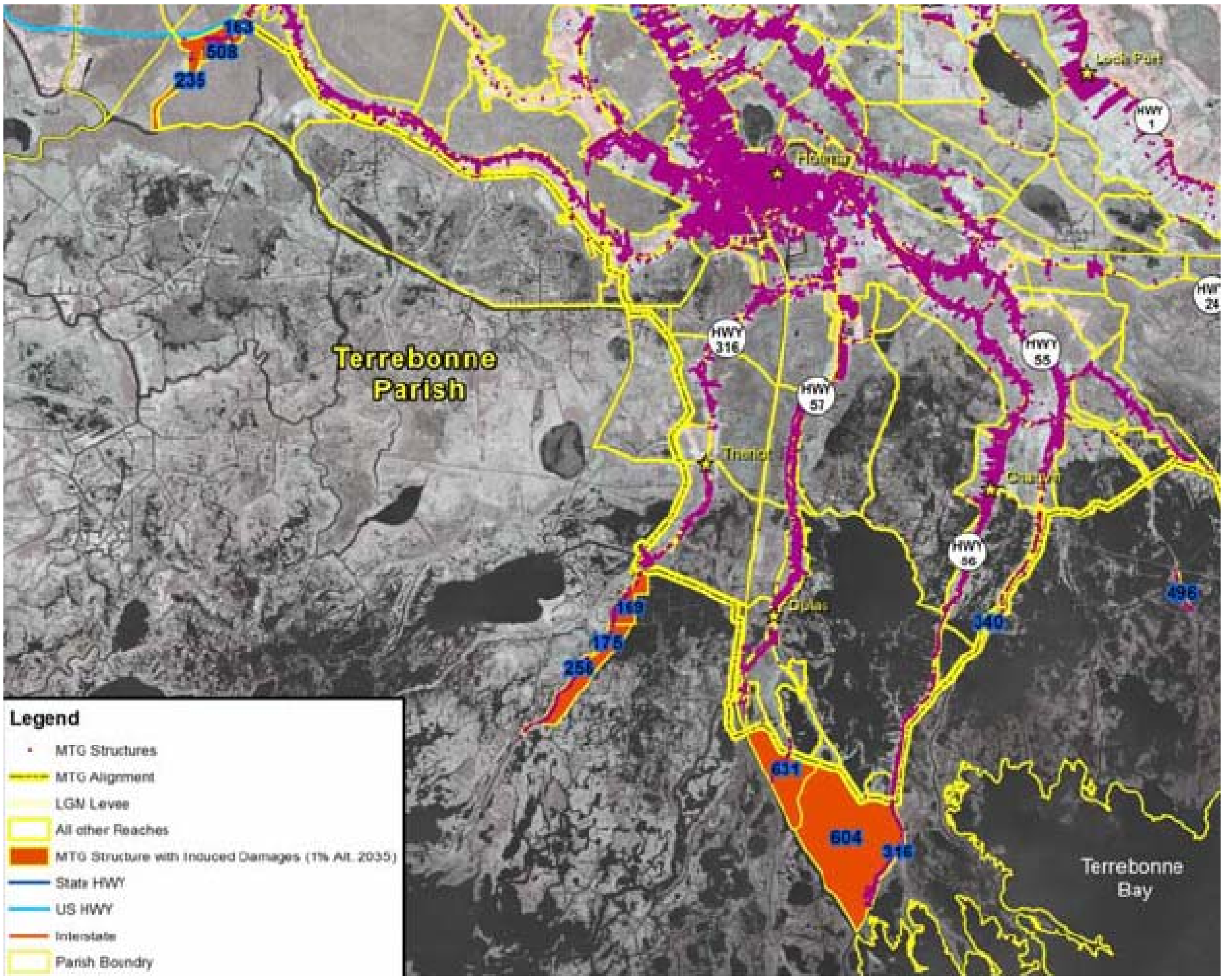

Figure 6-5. Economic Reaches With Possible Induced Damages

Induced damages were initially accounted for in the economic analysis as a negative value in the benefit calculation. For the base condition (2035), induced damages to areas outside the project levee reduced the expected annual benefits by between $14.5 and $22 million. Based on 2035 stage-probabilities, the probability that the target stage (equal to top of levee elevation or elevation where significant damages begin if no levee) would be exceeded within a given year with the Morganza project increases from 18 to 46 percent in Bayou Du Large and from 12 to 68 percent in Isle de Jean Charles. Over a 10-year period, the with- and without-project differences are less significant in these high risk areas. Local levee exceedance risk would increase from 87 percent to 100 percent in Bayou Du Large and from 71 percent to 100 percent in Isle de Jean Charles.

In order to prevent increased risk to people and structures, which are already located in high risk areas, a preliminary nonstructural plan has been developed. Presently, detailed information regarding the differences in frequency, depth, and duration of the flooding between the future without-project and future with-project conditions is not available. This detailed information typically would be assessed in light of the uses to which the particular land is zoned, and the appropriate mitigation methods, if any, would be implemented to address the effects of the Federal project. To ensure that the public is informed of all potential impacts of the project and to prevent future delays to project schedule, for purposes of this report, the worst case scenario (most expensive option) has been assumed, which would be a 100 percent buy-out of all of the structures in the impacted areas. Should this scenario prove to be the appropriate mitigation method, approximately 2,500 people would need to be relocated to areas behind the Federal levee system.

The benefits and costs of the buy-out plan have been incorporated into the total project cost and benefits analysis. The buy-out plan increases equivalent annual benefits for the 3% and 1% AEP alternatives by approximately $39 million and $57 million, respectively. The total real estate cost associated with this acquisition is estimated to be approximately $305 million as shown in table 6-7. The estimate of acquisition costs for residential structures includes the depreciated value of the improvement, the value of the land, moving costs, differential housing payment, payment of last resort, and administrative costs. The estimate of acquisition for the non-residential structures includes the depreciated value of the improvements, land value, moving costs, reestablishment costs, necessary and reasonable incidental costs, and administrative costs. Real Estate estimated an average Uniform Relocations Assistance cost for residential structures and one for non-residential structures, which was applied to all structures to be acquired.

Table 6-7. Preliminary Nonstructural Compensation Plan

	No. of Structures	Cost
Residential Acquisition	876	$248,712,800
Non-Residential Acquisition	134	$56,402,500
Total	1,010	$305,115,300

The potential induced damages and mitigation for economic damages would be further addressed during detailed design and supplemental NEPA documents. Individual investigation and devising mitigation for each structure, if appropriate, will be done during PED. Additional factors (height of structures vs. induced stages, type of residential structure, social concerns, etc.) would have to be investigated under PED. Each structure would have to be evaluated under PED to determine if mitigation is appropriate. Further modeling will be performed during PED to determine whether there is a potential taking. A Takings Analysis will be prepared during PED to address this issue, and at that time, it will be determined what real estate interest, if any, would be acquired.

6.5.2 Morganza to the Gulf Impacts on the Larose to Golden Meadow Project

Impacts on the existing Larose to Golden Meadow levee that would result from construction of the Morganza to the Gulf levee were evaluated. As previously shown in figures 6-3 and 6-4, stages on the western side of the Larose ring levee will be higher with the Morganza project in place than without Morganza. Morganza does not affect levee sections on the east side of the Larose to Golden Meadow ring levee. Initial Morganza to the Gulf levee lifts may not impact the performance of Larose to Golden Meadow, but future lifts would need to be coordinated to ensure that the Morganza project does not induce damages on Larose and that costs are allocated appropriately between projects.

Costs for potential future levee extensions/lifts and to eliminate potential induced damages on Larose have been added to the Morganza project at this time, however, final determination on cost allocation between the projects has not been made. The 2% AEP Larose levee design elevations "with" and "without" Morganza in place were used to determine the increment of inducements attributable to the Morganza project (table 6-8). The Morganza inducements were quantified for the Larose PAC report using the ADCIRC model. Consistent with LACPR modeling assumptions, the Morganza project was modeled as a non-overtopping levee in the ADCIRC model; therefore, results do not differentiate between the 3% and 1% AEP Morganza alternatives.

Table 6-8. Comparison of Larose Levee Elevations With and Without Morganza

Larose Levee Section	Approx. Section Length (miles)	Larose Authorized Elevations (ft)	2085 2% AEP Larose To Golden Meadow Levee Elevations (with wave berm)		Levee Height Increment* (ft)
			Without Morganza (ft)	With Morganza (ft)	
C-South	3.6	11.4	20	23	3
B-North	6.3	11.4-13.4	20	21.5	1.5
B-South	1.6	13.4	19.5	20.5	1
A-West	4.1	13.4	20	21	1

*For the Larose sections with induced stages, the increment is the difference between 2% AEP elevations with and without Morganza in place. Section C-North is part of both the Larose to Golden Meadow and Morganza to the Gulf projects.

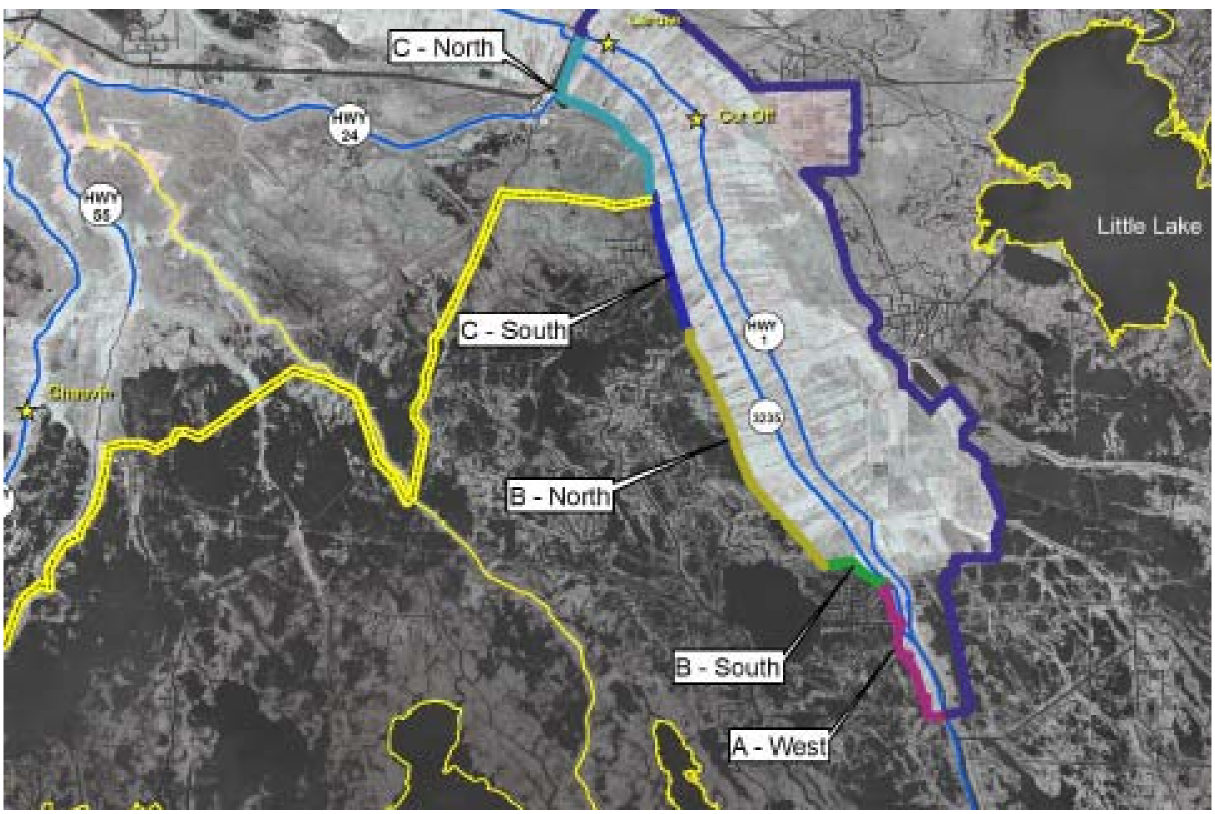

Figure 6-6. Morganza Reach L Tie-in to Western Side of Larose to Golden Meadow Ring Levee

Of the four levee reaches shown in table 6-8 (and in figure 6-6), the largest inducement is on Larose Section C-South. Table 6-9 compares the Larose still water elevations with and without Morganza for the same section. As shown in the table, the increment increases as the event becomes less probable (i.e. the larger the hurricane surge, the larger the inducement). Since the Larose to Golden Meadow project currently provides less than a 2% AEP level of risk reduction, the 3-ft stillwater and corresponding levee elevation increment was used rather than the 4.6 ft increment for Section C-South. The corresponding increments for the other reaches shown in table 6-7 were also used to develop costs.

Table 6-9. Comparison of Larose Still Water Elevations With and Without Morganza

Probability	Stillwater Elevation at Larose Section C-South		Increment (ft)
	Without Morganza (ft NAVD88)	With Morganza (ft NAVD88)	
2% AEP	11.2	14.3	3.1
1% AEP	14.6	18.2	3.6
0.2% AEP	18.3	22.9	4.6

Note that variations in side slopes (1 on 6 for Morganza; 1 on 3 for Larose) create variations in levee design elevations at same location.

If Congress does not re-authorize and fund improvements to the Larose to Golden Meadow ring levee to bring it up to a level of risk reduction comparable to the Morganza project, the costs to the Morganza project to mitigate the induced flooding could be around $125 million.

6.6 Comparison of Alternative Project and OMRR&R Costs

Levees and floodwalls are the largest component of the project costs and the biggest difference in project costs between the alternatives as shown in table 6-10.

Table 6-10. Project First Costs by Civil Works Feature

Work Breakdown Structure No. & Civil Works Feature Description	Estimated Cost (2011 Price Level) ($Millions)	
	3% AEP Alternative	1% AEP Alternative
02 Relocations	267	283
05 Locks	518	615
06 Fish & Wildlife Facilities	626	955
11 Levees & Floodwalls	2,428	5,259
15 Floodway Control & Diversion Structures	774	1,087
Construction Estimate Totals:	**$4,613**	**$8,200**
01 Lands and Damages	339	355
30 Planning, Engineering & Design	569	997
31 Construction Management	381	625
Project Cost Totals:	**$5,902**	**$10,177**

Note: Costs rounded to the nearest $1 million. Contingencies vary by category and range from 21 to 30 percent for the 3% AEP plan and from 26 to 35 percent for the 1% AEP plan.

The annual OMRR&R cost estimates used to compare the alternatives are shown in table 6-11. Annual OMRR&R costs are based on grass cutting for earthen levees and routine OMRR&R on all structures within the levee system, such as replacing flap gates, pumps, etc. The OMRR&R costs for the lock structure and all major floodgates (56-ft sector gates and larger) also include dewatering, which is estimated to be done once every 10 to 15 years.

Table 6-11. Comparison of Annual OMRR&R Costs for Alternatives

Alternative	Levee Grass Cutting		Structure OMRR&R ($millions)	Total OMRR&R ($millions)
	(acres)	($millions)		
3% AEP	3,500	$2.2	$3.2	$5.4
1% AEP	6,500	$4.0	$3.2	$7.2

Note: Costs rounded up to the nearest $100,000. OMRR&R costs include a 25 percent contingency. Does not include mitigation OMRR&R costs; those costs are added to the TSP.

Annual levee OMRR&R costs are based on over 3,500 acres of grass cutting for the 3% AEP alternative and over 6,500 acres of grass cutting for the 1% AEP alternative. Grass cutting is estimated to be needed 16 times per year. In the months of March to October, grass would likely need to be cut every 3 weeks. In the months of November to February, grass would likely need to be cut every 4 to 5 weeks.

6.7 Net Benefits and Benefit-Cost Ratios

Net benefits are based on the following benefit categories: residential and commercial (structure/content/vehicles), industrial (structures/contents), highways, streets, debris removal and cleanup, water supply, boats, and avoided structure raising costs. Costs and benefits for each alternative are shown in table 6-12.

Table 6-12. Cost and Benefit Comparison of PAC Alternatives

(2011 PRICE LEVEL, 3.75 % INTEREST RATE)	**3% AEP Alternative ($Millions)**	**1% AEP Alternative ($Millions)**
First Costs	**$5,902**	**$10,177**
Equivalent Annual W/O Project Damages	812	812
Equivalent Annual With Project Damages (Residual Damages)	409	124
Equivalent Annual Benefits (Damages Reduced)	403	689
Equivalent Annual Benefits During Construction	172	225
Total Equivalent Annual Benefits	586	924
Total Annual Costs	438	710
Equivalent Annual Net Benefits	148	214
B/C Ratio	1.34	1.30

6.8 Other Socioeconomic Benefits/Impacts

The following sections describe additional socioeconomic benefit and impact categories that are not factored into the benefit-cost ratio, including regional economic development, other social effects, and agricultural resources. For more information, refer to the Economic Appendix.

6.8.1 Regional Economic Development

The Regional Economic Development analysis measures the interdependence among industries and workers in an economy. This analysis uses a matrix representation of a region's economy to predict the effect of changes in one industry on others. The greater the interdependence among industry sectors, the larger the multiplier effect on the economy. Changes to government spending are projected to drive new levels of sales, employment, and income for each industry.

The construction of the Morganza to the Gulf levee system would yield significant increases in employment and gross regional product not only to the parishes of Terrebonne and Lafourche, but to Metro New Orleans and beyond. The 3% AEP alternative would generate an estimated $5.8 billion in gross regional product and 85,000 worker-years of labor annually during the construction of the levee system. The 1% AEP alternative would generate an estimated $10.2 billion in gross regional product and 155,000 worker-years of labor.

6.8.2 Other Social Effects

The Other Social Effects analysis considers the potential social ramifications of USACE actions so that decision makers and stakeholders are able to evaluate the social implications of each alternative and choose an alternative that will be judged as complete, effective, and fair.

The No Action Alternative would not reduce storm surge risk to residents of the Morganza evaluation area. Therefore, there is a high potential for extensive hurricane and tropical storm damage to continue occurring in the area. The apparent subsidence, or relative sea level rise, that has been taking place in the Morganza to the Gulf area, coupled with the anticipated population growth, is expected to magnify the flooding problems in the future. As a result, subsequent flooding events could cause even more damage to housing units, public facilities, and commercial structures than has previously been experienced. Under this alternative, the area would remain vulnerable to flooding, and long term resiliency would be hampered by the continued local efforts necessary to prepare for, and react to, flood events.

The 1% AEP alternative would result in the greatest potential for reduced flooding in the Morganza study area. This alternative would reduce the damages to housing units, public facilities, and commercial structures for 1 percent annual chance (and more probable) events. The area's social vulnerability would be reduced under this alternative, and thus, the potential for long-term growth and sustainability would be enhanced. Also, under this alternative, the area would be at a reduced probability of incurring the costs associated with clean-up, debris removal, and building and infrastructure repair as a result of flood events.

The 3% AEP alternative would also reduce the risk of flooding in the Morganza study area. However, this alternative would only provide risk reduction for 3 percent annual chance (and more probable) events. The area would still experience damage associated with less probable (more damaging) events.

6.8.3 Agricultural Benefits

Agricultural benefits due to inundation reduction have been quantified as a number of acres rather than a dollar value. Between 2035 and 2085, the average annual agricultural benefits range from approximately 610 to 1,680 acres for the 3% AEP alternative and 770 to 1,860 acres for the 1% AEP alternative. Even if a high estimate of the net revenue generated by an average annual acre were used in the analysis, the total agricultural benefits would only equal approximately 1 percent of the total inundation reduction benefits to structures, contents, and vehicles for each of the project alternatives. Thus, estimates of agricultural benefits were not included in the net benefit computations.

6.9 Relative Sea Level Rise Scenario Sensitivity Analysis

Since this project will be constructed over 40 or more years, there will be opportunities to re-evaluate relative sea level rise. If over time it appears that the actual RSLR rate is higher than expected, additional lifts can be added to levees, and the levee alignment may need to be further extended to the west and to the east. If RSLR rates are lower than expected, then final levee lifts will not need to be constructed, although structures may remain overbuilt. For example, to achieve the 1% AEP levee elevations at 2085 for the Low RSLR scenario, levee reach elevations could be reduced by 1 to 1.5 ft compared to the Intermediate RSLR elevations. For the High RSLR scenario, levee reach elevations would have to be increased by 3 to 6.5 ft.

Engineering data required for a complete economic analysis of the High and Low RSLR scenarios have not been generated; however, parametric designs and costs were used to compare the volumes and costs for the RSLR scenarios (not including levee extensions that may be needed for the High RSLR scenario). Table 6-13 summarizes the volume and cost increases or decreases. Cross-sectional areas were calculated for each of the levee reaches. The length of each reach was used to calculate the volumes of the levee reaches for each RSLR value. For each alternative, the Low RSLR volume was subtracted from the Intermediate RSLR volume to get the volume reduction, and the Intermediate RSLR volume was subtracted from the High RSLR volume to get the volume increase.

Table 6-13. Potential Change in Volume and Costs for Relative Sea Level Rise Scenarios

Alternative	RSLR Scenario	Average Cross-Sectional Area (sq.ft.)	Volume Difference Compared to Intermediate RSLR (cu.yd.)	Cost Difference Compared to Intermediate RSLR
1% AEP	Low (1.7 ft)	6,200	-3,600,000	-$98,500,000
	Intermediate (2.4 ft)	6,400	N/A	N/A
	High (4.8 ft)	9,000	49,100,000	$1,300,000,000
3% AEP	Low (1.7 ft)	2,300	-2,200,000	-$58,200,000
	Intermediate (2.4 ft)	2,400	N/A	N/A
	High (4.8 ft)	3,200	13,900,000	$376,500,000

If the High RSLR future scenario becomes as reality, the potential first cost increases to the project are estimated at $1.3 billion for the 1% AEP alternative and $377 million for the 3% AEP alternative. These first cost increases translate to 13 and 6 percent average annual cost increases. If the Low RSLR future scenario occurs, the potential savings to project first costs are $99 million for the 1% AEP alternative and $58 million for the 3% AEP alternative. These first cost decreases translate to approximately 1 percent decreases in average annual costs.

Stage probability functions for the alternative sea level rise scenarios have not been developed, making it impossible to precisely compute damages and benefits. In order to approximate damages and benefits for the Low RSLR scenario, the HEC-FDA modeled Intermediate RSLR damages for 2035 were held constant through the end of the period of analysis (as a “surrogate” for the Low RSLR scenario). The effect of this assumption is to allow no additional sea level rise beyond 2035. While the Intermediate RSLR increase up to 2035 would be greater than that associated with the Low RSLR scenario (stages for the 1% AEP would be approximately 0.2 ft higher on average), the amount of Intermediate RSLR by 2035 would be less than that associated with the 2085 Low RSLR scenario (stages for the 1% AEP would be approximately 1 ft lower on average). In general, over the period of analysis it would be appropriate to characterize the “surrogate” Low RSLR scenario as representing less increase than the Intermediate sea level rise scenario. It is believed that lower increases would be associated with lower without-project damages and lower benefits, therefore the without-project damages and benefits for the “surrogate” Low RSLR scenario would be lower than the Intermediate sea level rise scenario. Using this conservative estimate of benefits for Low RSLR (a reduction of 18 and 17 percent, respectively, for the 1% and 3% AEP project alternatives compared to the Intermediate RSLR scenario), and adjusted annual costs as previously described, would result in benefit-cost ratios of approximately 1.1 to 1 for both the 1% and 3% AEP project alternatives.

Approximation of the damages and benefits for the High RLSR scenario is more problematic given available data. It is expected that both damages and benefits would be higher with the High RSLR scenario. Consequently, Intermediate RSLR benefits are assumed as a conservative estimate of the High RSLR scenario. Using this conservative estimate of benefits for high sea level rise, and adjusted annual costs as previously described, would result in benefit-cost ratios of approximately 1.3 to 1 and 1.2 to 1, respectively, for the 1% and 3% AEP project alternatives.

7 Identification of a Tentatively Selected Plan

The 1% AEP alternative has been identified as the Tentatively Selected Plan (TSP) for the following reasons:

- **Higher net benefits**. According to WRDA Implementation guidance dated May 25, 2011, "recommendations in the PAC report should be made in consideration of maximizing excess benefits over costs." Both plans have positive benefit-cost ratios, but net benefits (excess benefits over costs) for the 1% AEP alternative plan are higher than the net benefits of the 3% AEP alternative plan.
- **Lower residual risk**. The 3% AEP alternative has a higher probability of overtopping and/or levee breaches than the 1% AEP alternative and therefore has higher residual damages than the 1% AEP alternative.
- **More adaptable**. The 1% AEP structures would be constructed at higher elevations than the 3% AEP structures, which allows more flexibility to adapt to relative sea level rise in the future. Although the total cost of the 1% AEP alternative is significantly higher than the 3% AEP alternative, not all funding and expenditures are required up front since earthen levees would be constructed in multiple lifts.

7.1 Plan Description

As a comprehensive approach to reduce hurricane and storm risk in portions of Terrebonne and Lafourche Parishes, the TSP is a hurricane and storm damage reduction levee system designed to provide 1% AEP surge risk reduction based on post-Hurricane Katrina criteria. The levee system consists of 98 miles of grass-covered earthen levees tying into US 90 near the town of Gibson in Terrebonne Parish and Hwy 1 near Lockport, LA in Lafourche Parish (see the project map in Attachment 1). Levee elevations for base conditions (2035) range from 10.5 to 24 ft NAVD88, and final levee elevations (2085) range from 15 to 26.5 ft NAVD88 with final levee widths from 282 to 725 ft.

Structures include 1 lock, 22 floodgates on navigable waterways (3 on Federally-maintained navigation channels and 19 on other canals and bayous), 23 environmental water control structures, 9 road gates, and fronting protection for 4 existing pumping stations. Structures on Federally maintained navigation channels include the HNC lock and floodgate (250-ft sector gate) and two 125-ft sector gates on the GIWW east and west of Houma. Fourteen 56-ft sector gates and five 20- to 30-ft stop log gates are located on various waterways that cross the levee system. Structure elevations range from 17 to 33 ft NAVD88.

Levees would be covered in grass to increase resilience in the case of wave overtopping. All of the transitions between levees and floodwalls would be armored with reinforced concrete scour protection.

Consistent with reducing hurricane and storm damages in an environmentally sustainable manner, the project is designed and would be operated to achieve coastal wetland conservation through the improved distribution of freshwater inflows to wetlands using environmental water control structures for tidal exchange. The specific designs and operating plans would be formulated in consultation with the interagency Habitat Evaluation Team.

Mitigation acres for the constructible features (levee reaches F-1, F-2, G-1; the HNC lock complex; and the Bayou Grand Caillou floodgate) include 136 acres of intermediate marsh and 780 acres of brackish marsh. No attempt was made to calculate mitigation requirements for the remaining programmatic project features; design details will be further refined and the impacts assessed in a future NEPA document.

As a sponsor funded additional work item, the HNC lock complex sill depth may be deepened from -18 to -23 ft NAVD88 in anticipation of future deepening of the HNC.

7.2 HNC Lock Complex

The largest structure in the Morganza to the Gulf project is the HNC lock complex, which consists of a 110-ft wide by 800-ft long lock with an adjacent 250-ft wide floodgate. The lock complex would have a 30.5 ft NAVD88 top elevation and either a -18.0 ft NAVD88 sill elevation consistent with current authorized channel depth, or a -23 ft NAVD88 sill elevation for adaptability to potential future channel depth (if funded as an additional work item by the non-Federal sponsor). When a storm approaches from the Gulf of Mexico, the lock and floodgate are closed, shutting the canal off to storm surge. During low water periods, the floodgate is closed, and marine traffic is locked through, reducing the quantity of salt water intrusion north of the project site.

7.2.1 Description of the HNC Lock Complex

Figure 7-1 is a conceptual drawing of the HNC lock complex. Features shown in figure 7-1 appear in bold in the following text:

- The HNC lock complex is generally oriented in a north-south direction approximately 3,000 ft south of the intersection of the HNC with Bayou Grand Caillou and is located in a **bypass channel** adjacent to the HNC on its west side.
- The lock structure consists of two lock gate monoliths (**gulf side lock gates and inland lock gates**), which house two sets of sector gates, and five U-frame **lock chamber** monoliths. A floodgate monolith adjoins the **gulf side lock gate** monolith and houses a **sector gate**, which is separated from the **gulf side lock gates** to the west by 59 ft. The five lock monoliths and the floodgate monolith are made of cast-in-place, reinforced concrete, and are pile supported.
- T-walls extend from both sides of the lock and floodgate to tie into the proposed Morganza to the Gulf hurricane system at **levee reach F-1** to the west and **levee reach G-1** to the east, transitioning to levee elevations +23.5 and +24 ft NAVD88 (in year 2085), respectively. Within the T-walls, there are a total of ten 5-ft wide by 10-ft high sluice gates—four between the floodgate and Levee Reach F-1, two between the lock and floodgate, and four between the lock chamber and closure dam.
- Guide walls and guard walls with steel sheet pile dolphin cells help align marine traffic to the lock and floodgate on both the north and south approaches.
- The lock and floodgate sector gates are normally remotely operated from a single **control house**, which is located at the south end of the lock chamber, on its east side. Below the **control house** is a visitor’s platform from where the lock operations can be observed. On the east side of the lock, there is an earthen reservation area that is built up above existing grade to +8 ft NAVD88. The lock can be accessed from this reservation area by either of two bridges that connect the lock gate monoliths to the reservation or by a driveway on the tie-in T-walls. Access to the floodgate is from the gulf side lock gate monolith or by boat. The reservation area contains an office building, an operation and maintenance building, a generator building, a perimeter road to access both ends of the lock, and a boat launch and dock. The maintenance dewatering structural systems for the lock and floodgate monoliths are stored on a nearby platform. Site utilities (electricity and potable

water) are routed beneath the HNC and tie into the reservation area. Sewage is treated by a package unit on site.

- A **closure dam** closes the existing HNC channel near the confluence of Bayou Platte and the HNC. The dam is underlain by a grid of soil-cement columns installed with the dry method of deep-soil mixing. The closure dam is a rock dam constructed to + 8 ft NAVD88 with a T-wall on top that provides protection to +30.5 ft NAVD88.

The project would be constructed “in-the-dry,” inside an earthen cofferdam excavation. Once the major project features are complete, the site would be re-watered and the last sections of the bypass channel dredged. Marine traffic would be rerouted through the lock and floodgate, and the HNC would be permanently closed by the rock dam.

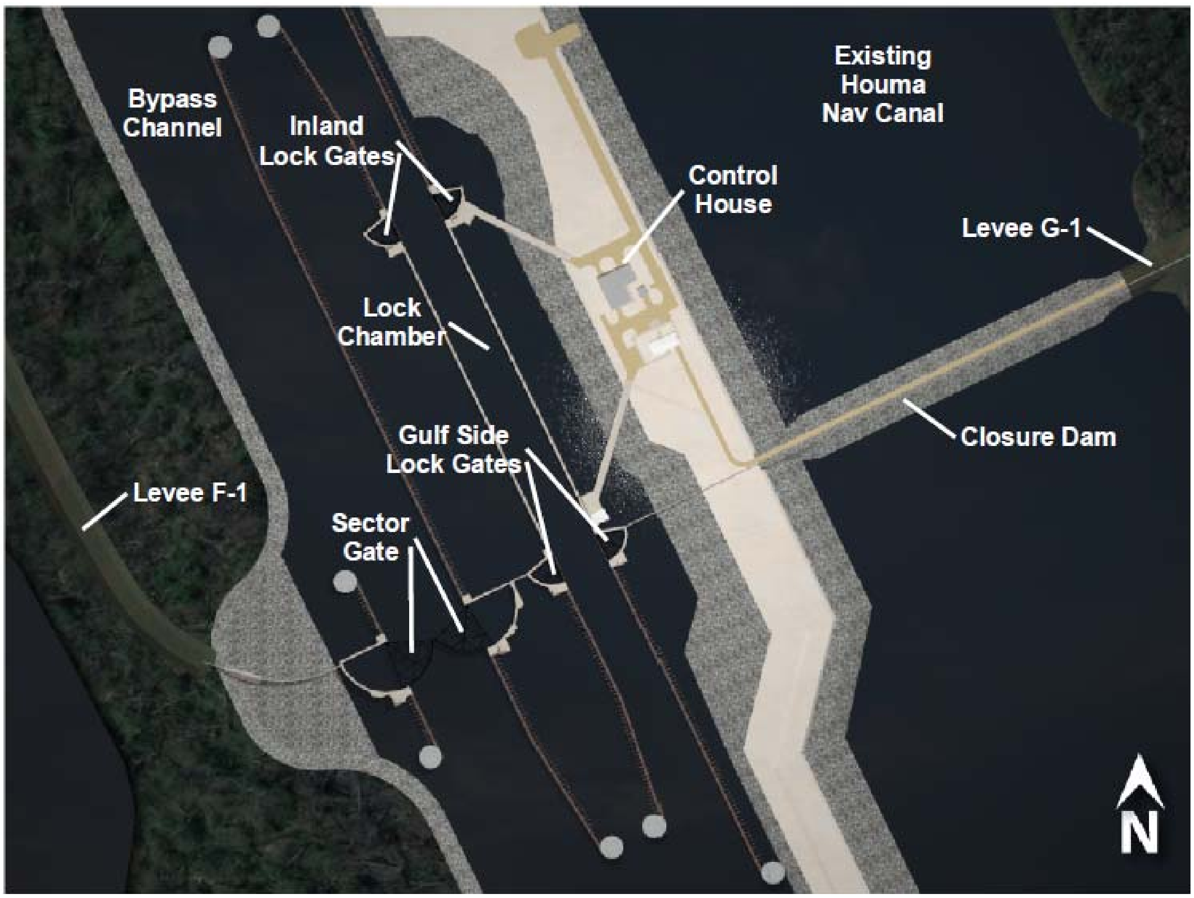

Figure 7-1. Conceptual Drawing of HNC Lock Complex

7.2.2 <u>Deepening the Lock Complex as a Sponsor Funded Additional Work Item</u>

The non-Federal sponsor has requested that, in lieu of constructing the HNC lock sill to an elevation of -18 ft NAVD88 as would be required by the currently authorized HNC project depth, the USACE construct the lock sill to an elevation of -23 ft NAVD88. Although this additional depth is not required for implementation of the Morganza to the Gulf project, the USACE could consider undertaking this additional work on the non-Federal sponsor's behalf if the non-Federal sponsor pays all incremental costs of this additional work, currently estimated at $32 million as shown in table 7-1. The USACE received a letter from the non-Federal sponsor on 18 May 2012 agreeing to pay for the full incremental cost of the deeper sill, as well as any incremental OMRR&R costs.

Table 7-1. Benefits and Costs for Authorized vs. Locally Preferred HNC Lock Complex Sill Depths

Feature	HNC Lock Complex Design Options Based on HNC Depths		Difference With and Without Sponsor Funded Additional Work Item
	As Currently Authorized	As Possibly Authorized in the Future	
Channel Depth	-15 ft	-20 ft	5 ft deeper
HNC Lock Complex Sill Elevation (3 ft below channel depth to allow for overdregde)	-18 ft	-23 ft	
HNC Lock Complex Wall Elevation	30.5 ft	30.5 ft	Same
HNC Lock Complex Cost	$615 million	$647 million	$32 million

*Costs are in October 2011 price levels and include contingencies; the total cost increment could be higher than the HNC lock complex cost increment if the deeper sill requires higher PED and S&A costs.

The sponsor funded additional work item does not change the Morganza to the Gulf project's hurricane and storm damage risk reduction benefits, nor would it substantially change environmental impacts. The benefit of the deeper sill is that it is more adaptable to potential future navigational needs for increases in channel depths.

The deeper sill adds approximately $32 million, which is a minor increase to the total project cost, so it would only negligibly lower the Morganza PAC benefit-cost ratio, and the project is still economically justified. The sponsor funded additional work item would prevent having to replace the HNC lock complex in the event that the HNC is deepened in the future. Conversely, if the lock sill elevation is built to -18 ft NAVD88 as part of the Federal plan, and the HNC is later deepened, most of the lock complex would need to be demolished and replaced. A detailed cost estimate to demolish and replace the -18 ft NAVD88 sill depth lock with a -23 ft NAVD88 sill depth lock has not been developed, but it is estimated that a fairly substantial portion of the original project cost (estimated 50 to 75 percent, or approximately $250 to $350 million) would be required to build the deeper lock complex. There would also be demolition costs to tear out portions of the old -18 ft NAVD88 sill HNC lock complex.

The OMRR&R of the HNC lock complex and the GIWW floodgate features that provide for inland waterway transportation is a Federal responsibility; however, the non-Federal sponsor will be responsible for any incremental OMRR&R costs associated with a deeper sill, which may require higher dredging costs. At this time, the annual OMRR&R costs in the PAC report are not at a level of detail to be able to differentiate between the annual OMRR&R cost difference between the TSP with and without the deeper sill. Incremental OMRR&R costs will be developed during the follow on PED phase.

7.3 Other Structures

In addition to the HNC lock complex, dozens of structures are located throughout the levee system including floodgates on navigable waterways, environmental water control structures, road/railroad gates, and fronting protection for existing pumping stations.

7.3.1 Floodgates

In addition to the HNC lock and 250-ft sector gate described in the previous section, the post-authorization Morganza to the Gulf project includes 21 other floodgates on navigable waterways ranging in size from 20-ft stop-log gates to 125-ft sector gates. Figure 7-2 is a conceptual drawing of a 56-ft sector gate and figure 7-3 is an example site plan for the same type of floodgate.

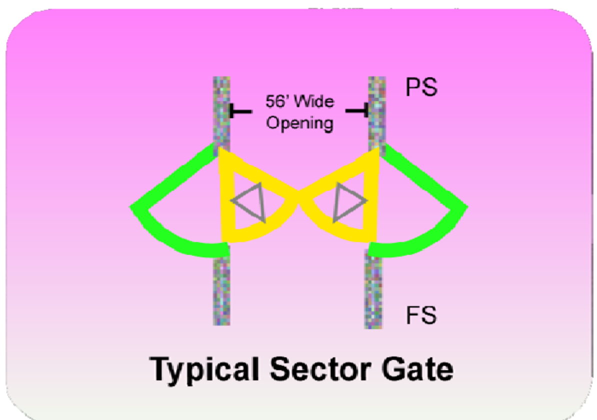

Figure 7-2. Conceptual Drawing of a Typical Sector Gate
PS = Protected Side; FS = Flood Side

Structures were designed to provide enough width for vessel passage and enough flow cross sectional area at the gate sites so that the constricted flow velocities would neither exceed the navigational criteria nor result in channel scouring problems. The assumption for the PAC report is that all currently navigable waterways must remain so after the project is put in place, however, the number/sizes of gates may be able to be reduced during PED with additional data on navigation.

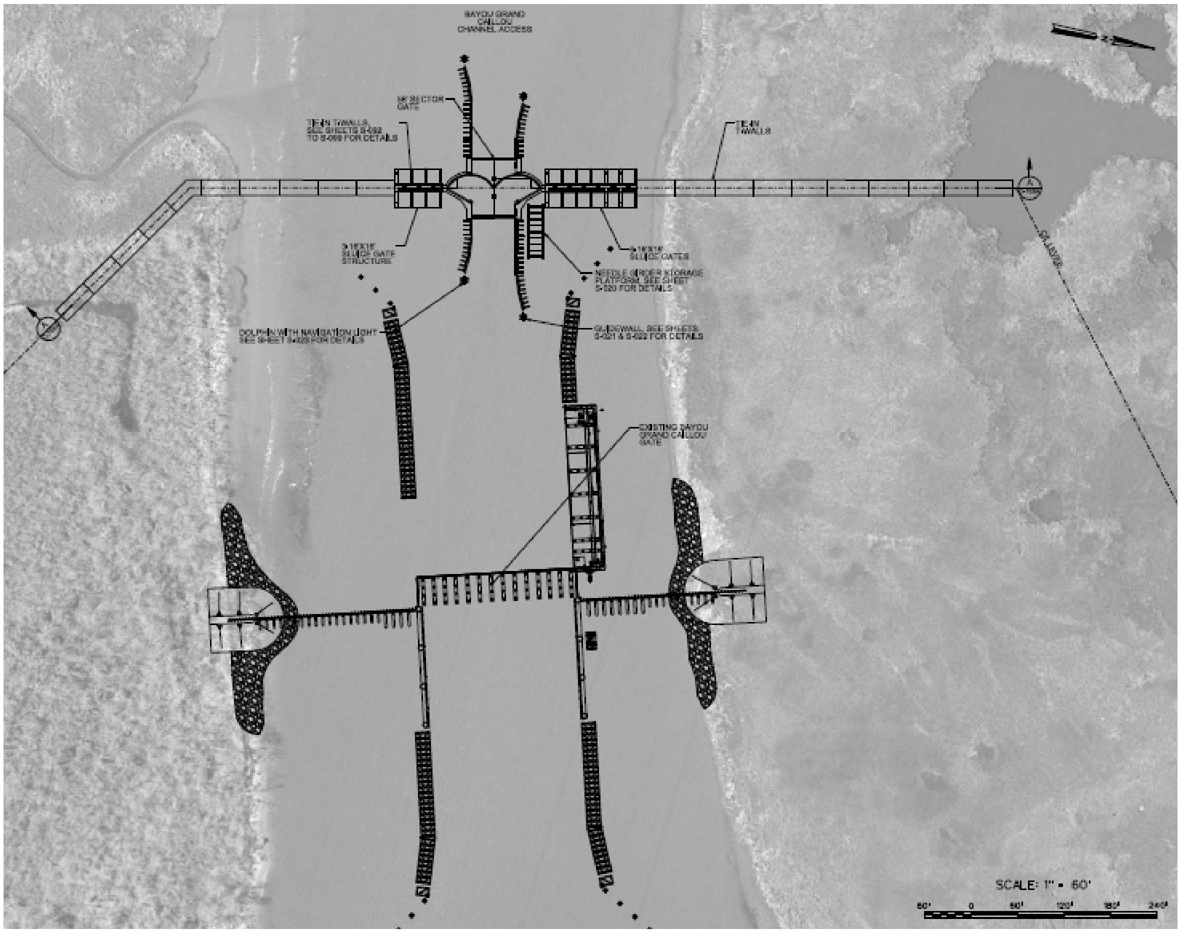

Figure 7-3. Example 56-ft Sector Gate Site Plan (Bayou Grand Caillou)

7.3.2 <u>Environmental Control Structures</u>

Environmental control structures are located at 23 locations within the levee system. The purpose of the environmental control structures is to provide hurricane and storm damage reduction during storm conditions and to match existing drainage patterns during non-storm conditions. Environmental control structures consist of box culverts and sluice gates allowing tidal exchange. The number of 6-ft by 6-ft or 5-ft by 10-ft culverts at each location varies from one to nine. The typical configuration is six 6-ft by 6-ft box culverts as noted in the conceptual drawing in figure 7-4.

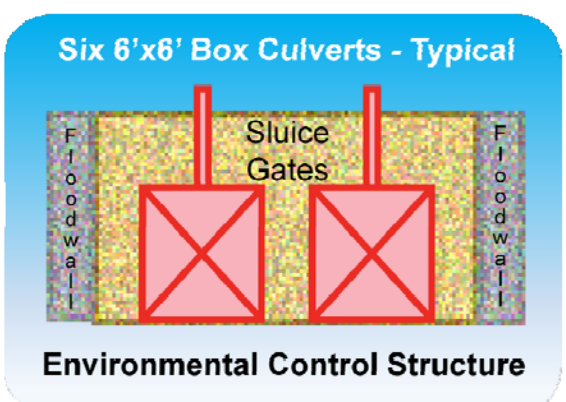

Figure 7-4. Conceptual Drawing of a Typical Environmental Control Structure

7.3.3 Pump Stations

Fronting protection is provided for several existing pumping stations, including the Madison, Pointe aux Chenes, Elliot Jones (Bayou Black), and Hanson Canal pump stations. Features associated with the construction of fronting protection include T-walls and butterfly gate valves as shown in figure 7-5. All fronting protections would be constructed on the flood side of the existing protection. Based on site visits, the discharge pipes extend far enough that additional pipes are not needed. Butterfly valves would be opened to allow pumping discharge for interior drainage or closed to prevent backflow during storm conditions.

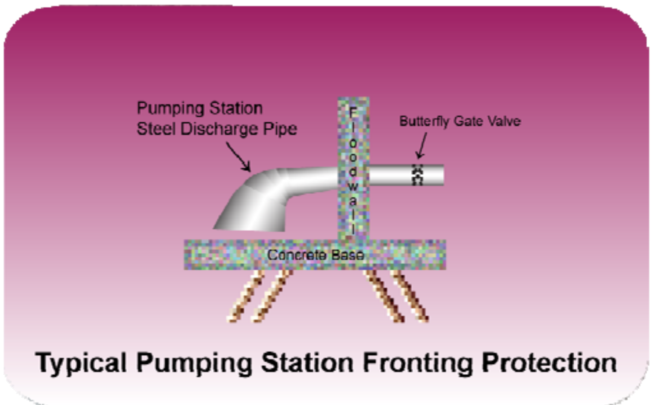

Figure 7-5. Conceptual Drawing of Typical Pumping Station Fronting Protection

7.3.4 Roadway Gates

The levee alignment impacts several state and parish highways and roads and the Union Pacific Railroad. At the points of intersection with the levee, the options are either to construct ramps over the levee or permanent floodgates. These structures would remain open except for times of anticipated flooding, which at that time they would be closed and remain closed until the flood threat subsided. Roadways affected by this project include LA Highway 1, LA Highway 25, LA Highway 182 (Bayou Black Drive), LA Highway 315 (Bayou Du Large Road), Four Point Road, LA Highway 56, LA Highway 55, LA Highway 665 (Point aux Chenes Road), LA Highway 24, LA Highway 3235, and a private road on NAFTA property. All roadways and the railroad would have a swing gate, except LA 182 which would have a ramp. For LA 182, alternate access for locals will need to be made available during the construction of the earthen ramp, which will need to be raised each time the levee is raised. The features associated with construction of each roadway gate structure are a steel swing gate, concrete monolith, and traffic control devices.

7.4 Structure Operation Plans

The following sections describe the operation plan for the HNC lock complex, GIWW floodgates, other floodgates on navigable waterways, and environmental control structures.

7.4.1 Operation of HNC Lock Complex

The primary purpose of the HNC lock and floodgate structure is for storm surge control. Secondary benefits include prevention of saltwater intrusion from impacting drinking water quality at the Houma Water Treatment Plant, and protection of marsh areas inside the system along the HNC channel. Future operation of the lock for purposes of the LCA program is discussed in section 10.1.7, LCA Plan Uncertainties.

The lock operation plan has two triggers based on the two purposes. First, maintaining a safe water elevation in the channel for storm control and navigation, and second, controlling chloride levels at the Houma Treatment Plant and controlling salinity to protect environmental habits upstream of the structure.

The HNC complex (HNC lock, HNC floodgate, and Bayou Grand Calliou floodgate) will be closed for storm surge control if:

1. The water surface elevation on the staff gage reaches +2.5 feet NAVD88 downstream of the lock when there is a named tropical storm in the Gulf.
2. If the National Weather Service issues a hurricane warning for the project area, the gates will be closed, if they have not already been closed due to condition (1) above.

The HNC lock and floodgate will be closed for salinity control if:

1. Flows in the Atchafalaya River flows are below 100,000 cfs as measured on the Simmesport gage (USGS 07381490 Atchafalaya River at Simmesport, LA) or
2. If a gage on the outside of the HNC Lock exceeds a salinity value that has been correlated with preventing exceedance of the maximum allowable chloride level of 250 ppm as defined in EPA's secondary drinking water standard at the Houma Treatment Plant. The structure should be closed for at least 12 hrs and fluctuations in chloride levels should be monitored and recorded hourly.

The HNC complex will be opened after a hurricane or other high water event has passed. The gates may be opened when all of the following criteria have been met:

1. The differential between the interior water level and exterior water level is equal to or less than the +1.0 feet as measured on the upstream and downstream staff gage respectively.
2. Navigation can resume, as soon as the hurricane and small craft warning no longer apply to the project area, and the channel has been cleared of obstructions.
3. If the salinity level at Bayou Grand Calliou at Cocodrie (USACE 76305) falls below 13 ppt.
4. After monitoring chloride levels over the 12 hour period indicates chloride levels have stabilized and are below the maximum allowable level of 250 ppm.

It is important to note the operational plan is preliminary and will be refined in the future once the detailed structure design is completed. In order to operate the HNC lock according to the criteria laid out in this plan, a monitoring program must be in place.

7.4.2 Operation of GIWW Floodgates

GIWW floodgates at Houma and Larose will be closed for storm surge control if:

1. The water surface elevation on the staff gage reaches +2.5 feet NAVD88 at the floodgates when there is a named tropical storm in the Gulf.
2. If the National Weather Service issues a hurricane warning for the project area, the gates will be closed, if they have not already been closed due to condition (1) above.

7.4.3 Operation of Environmental Control Structures

Environmental control structures will be closed for storm surge control if:

1. The water surface elevation on the staff gage reaches +2.5 feet NAVD88 at the flood gates when there is a named tropical storm in the Gulf.
2. If the National Weather Service issues a hurricane warning for the project area, the gates will be closed, if they have not already been closed due to condition (1) above.

The environmental control structures would be used for drainage of isolated areas within a certain timeframe and maximum inundation of the marsh areas. Refer to the Engineering Appendix for more details.

7.4.4 Operation of Other Floodgates

Floodgates on navigable waterways will be closed for storm surge control and tidal flooding if similar conditions occur to those outlined in recent TLCD permit applications. The floodgates will remain open at all times except during tropical storm events, including hurricanes or other extreme tidal events. Gages will be installed upstream and downstream of each structure. When water levels at the gates approach +2.5 ft NAVD88, the floodgates shall be closed until the differential between the interior water level and exterior water level is equal to or less than the +1.0 feet as measured on the upstream and downstream staff gage respectively. The trigger elevation may vary at different structure locations and will be further refined in the final PAC report.

The number of times closure occurs each year under existing conditions will depend on tropical storm events and location of the structures. The structures located south and east in close proximity to the Gulf are influenced by tidal exchange. These structures would reach the closure stage more frequently than those located in the north and west areas of the project. Proposed structures are expected to be operated in a similar manner to existing flood gates owned and constructed by the locals. Table 7-2 summarizes recent historical closures and frequency of closure by location and year. Most closure durations were less than 48 hours.

Table 7-2. Number of Gate Closures Between 2001 and 2012

Gate	Total Number of Closures from 2001 to 2012	Maximum Number of Closures Per Year
Bayou Terrebonne	45	8
Little (Petit) Caillou	29	9
Lower Bayou Du Large	5	2
Upper Little Caillou Barge	4	1
Humble Canal	9	5

Source: Terrebonne Levee and Conservation District

7.4.5 Adapting Operation Plans to Future Sea Level Conditions

Under future conditions, closure frequency could increase if the closure trigger is not adjusted to account for sea level rise. For example, under existing conditions, HNC floodgate closure (based on a 2.5-ft closure stage only, not the salinity triggers) would occur approximately 1.5 days per year. If the trigger remained the same through 2085, low RSLR would require closure 5 days per year by 2035 and 168 days per year by 2085 (refer to RSLR rates in table 3-1). Intermediate RSLR would require closure for 15 days per year by 2035 and 354 days per year by 2085. High RSLR would require closure for 24 days per year in 2035 and 365 days per year in 2085. To prevent frequent structure closings, operation plans will need to be re-evaluated periodically and closure trigger elevations may need to be increased if significant sea level rise occurs.

In the future, the non-Federal sponsor may desire more frequent closure of structures to reduce damages from higher stages unrelated to storm events, however, that operational purpose is not covered by the RPEIS for this PAC report. In the event that the project purpose and operation of structures changes in the future, impacts to navigation and development could be reduced by adding a second set of gates to turn floodgates into locks in conjunction with additional pumps behind the levee system. If these changes in operation are requested in the future, a supplemental NEPA document and additional PAC report would be required.

7.5 Real Estate Plan

The Non-Federal Sponsor has responsibility for and receives credit for obtaining Lands, Easements, Rights-of-Way, Relocations, and Disposal Areas (LERRDs). The Real Estate Plan, which is provided as an appendix to this report, presents the real estate requirements and costs for the PAC Report, in accordance with E.R. 405-1-12 (Chapter 12).

7.5.1 Lands, Easements, and Rights-of-Way

The majority of the acreage affected by the project consists of marsh or wooded wetlands. Other lands impacted include woodland, agricultural (cane land), industrial waterfront on the GIWW, residential waterfront lots at the community of Waterproof, and mixed-use waterfront lots on Bayou Petit Caillou and Bayou du Large ("Mixed-use" refers to recreational "camps" or residential waterfront lots). The Right-of-Way in Lafourche Parish consists mostly of marsh and open water. The majority of the staging areas for construction of this project would be located within the Right-of-Way for the levee footprint or existing Right-of-Way.

The Real Estate Plan references LERRDs for three different types of acquisitions: 1) The LERRDs required for construction and OMRR&R of the project (affecting approximately 580 landowners), 2) the LERRDs required for future lift borrow (affecting approximately 325 landowners), and 3) the LERRDs required in areas affected by induced flooding (affecting approximately 1,010 landowners).

Estates required for the project would include Fee, Excluding Minerals (With Restriction on Use of Surface), perpetual Flood Protection Levee Easements, Temporary Work Area Easements, and Temporary Access Easements (Non-Material Deviation from Standard Estate).

7.5.2 Utility Relocations

Facility/Utility Relocation data was collected and detailed by the USACE New Orleans District, Engineering Division, Design Services Branch Relocations Team. A separate Relocations Report, containing relocation costs, was submitted as a reference to the Engineering Appendix of the PAC Report.

There are multiple pipeline crossings throughout the project. Some pipeline owners have directionally drilled pipeline crossings for currently planned local levees and with anticipation of this project in mind. During the next phase of design, as more information becomes available, alternatives for pipeline crossings will be further evaluated. Directional drilling is the preferred alternative, but many times more expensive than other methods. Other alternatives may include bridging over the levee or laying the pipe over the levee slope and crown support with temporary saddles or short piles until it can be incorporated into future lifts that keep the pipe above the storm still water level. Abandoned pipelines should be removed, but in some cases may be grouted and capped on both ends within the levee right-of-way. Oil and gas wells would not be relocated; instead, the levee alignment would be changed, or T-walls used, during the project Plans and Specifications phase to avoid them.

In addition to underground lines, the proposed highway gate closures and ramp would require relocation of overhead lines (poles, electric, cable, telephone). For the floodwalls, it includes passing the gas and water lines through a sleeve. For the ramp at LA 182, it includes directionally drilling the gas and water lines.

7.6 Borrow Materials

Levees will be constructed using a combination of sidecast and hauled-in borrow materials. Adjacent sidecast was used for the pre-load section only. Haul in scenarios were used for the initial (first) lift and projected subsequent lifts. Borrow pits are oversized to offset the potential for encountering organics, expected losses, etc.

7.7 Mitigation Plan

USACE policy is to ensure that adverse impacts to significant resources have been avoided or minimized to the extent practicable and that remaining, unavoidable impacts have been compensated to the extent justified. The appropriate application of mitigation is to formulate an alternative that first avoids, then minimizes, and lastly, compensates for unavoidable adverse impacts. In the development of the project, features that were incorporated to avoid and minimize potential adverse environmental effects included, where practical, the placement of levees at locations that would avoid or minimize effects on wetlands or other significant features of the project area. The sizing of floodgates and environmental control structures was done to minimize indirect impact to wetlands in the interior of the system. A system wide hydrodynamic model and structure specific models were developed and run to verify that no indirect impacts to enclosed wetlands occurred.

An interagency Habitat Evaluation Team was formed to use Wetland Value Assessment (WVA) methodology to assess the quality of wetlands of the area, make a determination of the effects various aspects of the project on future conditions, and calculate the amount of mitigation required to compensate for impacts caused by the constructible features of the project. A description of the WVA methodology, analysis, and assumptions made by the HET may be found in Appendix F of the RPEIS.

7.7.1 Programmatic Features

While the Habitat Evaluation Team made a preliminary assessment of total wetland impacts resulting from the project (4,113 acres as described in section 6.4.1, Direct Impacts), no attempt was made to calculate exact mitigation requirements for the programmatic features. Design details of each of the programmatic elements will be further refined and the impacts assessed in a future NEPA document. At that time, the wetland impacts for those areas will be reevaluated. WVAs will be done for those areas and a mitigation plan developed in accordance with the requirements of 33 CFR Part 332. It is anticipated that the future mitigation plans would be similar to the following mitigation plan for the constructible features.

7.7.2 Constructible Features

Estimated required mitigation acres for the constructible features include 136 acres of intermediate marsh and 780 acres of brackish marsh. For the constructible features (levee reaches F-1, F-2, G-1; the HNC lock complex; and the Bayou Grand Caillou floodgate), compensatory mitigation alternatives considered the purchase of mitigation credits from an approved mitigation bank and USACE constructed in-kind mitigation. The WRDA of 2007 requires that the USACE first consider using commercial mitigation banks to provide compensation for environmental impacts to wetlands. The USACE determined that the use of mitigation banks for the constructible features was not feasible for the following reasons: (1) No mitigation banks for intermediate, brackish, or saline marsh are available in the vicinity of the project area; (2) project structures would be constructed using clay material dredged from areas adjacent to the proposed structures; however, the overburden consists of approximately 5 ft of organic material unsuitable for use as construction material. To reduce project costs, the USACE proposes to use this organic material to create/restore coastal marsh habitat to compensate for losses resulting from the project. If the amount of the overburden material is insufficient, additional material would be obtained from offsite sources. There are two mitigation banks in the area that would be considered for the programmatic features. They may potentially provide credits for fresh marsh, cypress/tupelo gum swamp, and bottomland hardwoods. This mitigation plan is intended to provide compensation for direct impacts associated with the constructible elements of the project. The Habitat Evaluation Team determined that no indirect impacts to wetlands would result from the project.

The proposed mitigation actions include construction of marsh to restore eroded and subsided wetlands in the project area. The mitigation work plan includes the following features, which are further described in the RPEIS:

- **Containment Dikes:** Dikes would be used at each marsh restoration site to contain placed earthen materials until the materials have consolidated and wetland vegetation has become established.
- **Dike Degradation:** The dikes around mitigation sites and cells would be designed to slowly deteriorate and subside to the level of the adjacent marsh substrate, thereby promoting the tidal exchange of water.
- **Target Elevations:** The target elevations of placed and consolidated fill at each site would be determined through geotechnical analyses. The final result of the material placement would be a combination of wetlands and shallow open water habitat within the site. Slurry would be allowed to overflow over existing emergent marsh vegetation within the proposed disposal areas, but would not be allowed to exceed a height of about one foot above the existing marsh elevation.
- **Vegetation:** The establishment of vegetation on marsh areas would provide stability and reduce erosion.
- **Access Corridors:** Access corridors to mitigation sites would be a maximum of about 200 feet wide and would cross over uplands, wetlands, and shallow open water as necessary.
- **Flotation Access Corridors:** Channels would be excavated as needed in shallow open water areas to allow construction equipment to access sites.
- **Existing Levee Access Corridors:** If construction equipment and discharge pipelines are placed across or along the crown of existing levees in the project vicinity, the levees may

be refurbished using borrow material from adjacent shallow open water to facilitate their use as access corridors for construction equipment and discharge pipelines.

- **Staging Areas:** The construction or designation of staging areas may be necessary for construction equipment and for the unloading of pipeline and other equipment necessary to perform disposal operations.
- **Board Roads:** Temporary board roads may be constructed along access corridor alignments and staging areas wherever emergent marsh exists. Board roads would be removed when work is completed.

The non-Federal sponsor would be responsible for OMRR&R of functional portions of work as they are completed. On a cost-shared basis, the USACE would monitor completed mitigation to determine whether additional construction, invasive species control, and/or planting are necessary to achieve mitigation success. The USACE would undertake additional actions necessary to achieve mitigation success in accordance with cost sharing applicable to the project and subject to the availability of funds. Once the USACE determines that the mitigation has achieved initial success criteria, monitoring would be performed by the non-Federal sponsor as part of its OMRR&R obligations. If, after meeting initial success criteria, the mitigation fails to meet its intermediate and/or long-term ecological success criteria, the USACE would consult with other agencies and the non-Federal sponsor to determine whether operational changes would be sufficient to achieve ecological success criteria. If, instead, structural changes are deemed necessary to achieve ecological success, the USACE would implement appropriate adaptive management measures in accordance with the contingency plan and subject to cost sharing requirements, availability of funding, and current budgetary and other guidance.

7.8 Plan Costs

Table 7-3 shows the cost breakout of the TSP plan features and/or categories. The Fish & Wildlife Facilities category includes both the cost of the environmental control structures and additional mitigation costs. Part of the total mitigation cost is already accounted for in the construction cost to dispose of the top 5 ft of borrow for first lift levees, which is not suitable for levee building; approximately 12,305,000 cubic yards would be available for marsh creation. Using Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) program marsh creation assumptions and water depths of between -2.25 and -3.5 (varies by reach), the 12,305,000 cubic yards could create approximately 1,175 acres of marsh. Since more than 1,175 acres of marsh mitigation is needed, the 1,175 acres were subtracted from the total marsh acres needed to calculate the "additional" mitigation costs.

Table 7-3. TSP Costs by Civil Works Feature

Work Breakdown Structure No. & Civil Works Feature Description	Estimated Cost Oct 2011 Price Level ($Millions)
02 Relocations	283
05 Locks	615
06 Fish & Wildlife Facilities	955
11 Levees & Floodwalls	5,259
15 Floodway Control & Diversion Structures	1,087
Construction Estimate Totals:	**$8,200**
01 Lands and Damages	355
30 Planning, Engineering & Design	997
31 Construction Management	625
Project Cost Totals:	**$10,177**

Note: Costs rounded to the nearest $1 million. Lock costs do not include sponsor funded additional work item.

7.9 Annual OMRR&R Costs

Annual OMRR&R costs for the TSP are shown in table 7-4. The Federal OMRR&R costs are for the GIWW and HNC lock complex structures. With the sponsor funded additional work item, the HNC lock complex OMRR&R costs could be slightly higher; any additional costs attributable to the deeper sill (e.g. higher dredging costs) would be the responsibility of the non-Federal sponsor. Levee OMRR&R costs are based on mowing 98 miles of earthen levees and dewatering and refurbishing numerous floodgates and a lock every 10 to 15 years. Future levee lifts are considered construction costs, not OMRR&R costs.

Table 7-4. Annual OMRR&R costs for the TSP

Project Feature	Federal	Non-Federal	Total
Structures	1,574,000	1,552,000	3,126,000
Levees	0	3,927,000	3,927,000
Mitigation	0	231,000	231,000
Total	**$1,574,000**	**$5,710,000**	**$7,284,000**

All annual OMRR&R costs include a 25 percent contingency. Numbers rounded up to nearest 1,000.

Non-Federal sponsor OMRR&R responsibilities would commence as soon as each project feature is complete. For example, once a levee lift for a particular reach is constructed and covered in grass, maintenance (i.e. mowing) would start. Based on the assumed implementation schedule, the first feature of the project to be completed would be first-lift levees on reaches F-1, F-2, and I-1 by 2016.

8 Plan Implementation

The following sections describe division of plan responsibilities, work in kind credit, and non-Federal sponsor financing.

8.1 Federal and Non-Federal Cost-Sharing

The CPRAB and TLCD have indicated their desire to act as non-Federal sponsors for this project and to perform work-in-kind in order to provide interim flood protection, expedite project completion and satisfy a portion of the non-Federal cost share. The non-Federal share of project costs is approximately $10,177,200,000 (October 2011 dollars), which would be provided over a 50 to 60 year construction period. The non-Federal sponsor would assume responsibility for OMRR&R of the hurricane and storm damage reduction system, except for those features identified as Federal responsibilities in section 8.2 of this report.

The non-Federal sponsor is required to provide all LERRDs for the project. The non-Federal sponsor requests that the entire remaining non-Federal share (other than LERRD requirements) be provided as work-in-kind rather than cash. Any levees or structures that are part of the Morganza to the Gulf post-authorization project and conform to USACE standards could be possible work-in-kind. The construction cost of this potential work in kind is estimated to be approximately $2,923,800,000. The estimates in table 8-1 are subject to change as the design progresses and features become more refined.

Table 8-1. Federal and Non-Federal Cost-Sharing Summary

Cost Share Feature	Project Costs ($1000s) October 2011 price level
Total Project Cost	$10,177,200
Federal Share (65 percent of Total Project Cost)	6,615,200
Non-Federal Share (35 percent of Total Project Cost)	3,562,000
Value of Proposed Work-in-Kind (non-Fed share minus LERRDs)	2,923,800
LERRDs	638,200
Additional Cash Required	0

Costs rounded to nearest hundred thousand dollars. Does not include sponsor funded additional work item.

8.2 Federal Responsibilities

The Federal government will be responsible for planning, engineering, design, and construction of the project in accordance with the applicable provisions of Public Law 99-662 (WRDA of 1986). The Government, subject to Congressional authorization and the availability of funds and using those funds provided by the non-Federal sponsor, shall expeditiously construct the project, applying those procedures usually applied to Federal projects, pursuant to Federal laws, regulations, and policies. In addition, the Government shall operate, maintain, repair, rehabilitate, and replace the two floodgate structures along the GIWW and all components of the HNC lock complex, at no cost to the non-Federal sponsor.

8.3 Non-Federal Responsibilities

Federal implementation of the recommended project would be subject to the non-Federal sponsor agreeing to comply with applicable Federal laws and policies, including but not limited to the following:

a. Provide 35 percent of total project costs as further specified below:

1. Provide 25 percent of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

2. Provide, during the first year of construction, any additional funds necessary to pay the full non-Federal share of design costs;

3. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the project;

4. Provide, during construction, any additional funds necessary to make its total contribution equal to 35 percent of total project costs;

b. Shall not use funds from other Federal programs, including any non-Federal contribution required as a matching share therefor, to meet any of the non-Federal obligations for the project unless the Federal agency providing the Federal portion of such funds verifies in writing that expenditure of such funds for such purpose is authorized;

c. Not less than once each year, inform affected interests of the extent of protection afforded by the project;

d. Agree to participate in and comply with applicable Federal floodplain management and flood insurance programs;

e. Comply with Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12), which requires a non-Federal interest to prepare a floodplain management plan within one year after the date of signing a project cooperation agreement, and to implement such plan not later than one year after completion of construction of the project;

f. Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with protection levels provided by the project;

g. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the level of protection the project affords, hinder operation and maintenance of the project, or interfere with the project's proper function;

h. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;

i. For so long as the project remains authorized, operate, maintain, repair, rehabilitate, and replace (OMRR&R) the project or functional portions of the project, including any mitigation features, at no cost to the Federal Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government (except the HNC lock complex and the GIWW floodgate features of the project for which the responsibility for OMRR&R is assigned to the Government under Section 1001(24) of WRDA 2007);

j. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

k. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;

l. Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations (CFR) Section 33.20;

m. Comply with all applicable Federal and State laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141- 3148 and 40 U.S.C. 3701 – 3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c et seq.);

n. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended (42 U.S.C. 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-Federal sponsor with prior specific written direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction;

o. Assume, as between the Federal Government and the non-Federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project;

p. Agree, as between the Federal Government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA; and

q. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), and Section 103(j) of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2213(j)), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each non-Federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element.

r. Shall not use any project features or lands, easements, and rights-of-way required for such features as a wetlands bank or mitigation credit for any other project;

s. Pay all costs due to any project betterments or any additional work requested by the sponsor, subject to the sponsor’s identification and request that the Government accomplish such betterments or additional work, and acknowledgement that if the Government in its sole discretion elects to accomplish the requested betterments or additional work, or any portion thereof, the Government shall so notify the Non-Federal Sponsor in writing that sets forth any applicable terms and conditions.

8.4 Implementation Sequencing and Requirements

Subject to project authorization, funding, and regulatory approval, construction is scheduled to begin in 2015 as shown in table 8-2. The schedule assumes a complete risk reduction system in place by 2024, with additional levee lifts so that the entire system meets 1% AEP standards by year 2035, and final levee lifts to account for sea level rise and subsidence completed by around 2070. The Morganza to the Gulf project requires construction authorization and the appropriation of construction funds. A continuous funding stream is needed to complete this project within the anticipated timeline, which requires continuing appropriations from Congress and the State of Louisiana in order to fund the detailed design phase and fully fund construction contracts.

Table 8-2. Implementation Milestones

Milestone	Dates
Public Review Draft	Jan 2013
Civil Works Review Board	May 2013
State and Agency Review	May – June 2013
Sign the Report of the Chief of Engineers	2013
Chief's Report sent to the Assistant Secretary of the Army (Civil Works)	2014
PED Phase Continues	2014 – 2015
Real Estate Acquisition and Construction Contracts Advertising and Award	2014 – 2015
Project Construction Starts	2015

The Morganza to the Gulf project does not start to function as a system or achieve its benefits until all first lift levees and structures are in place. Preliminary construction sequencing is based on availability of information required for construction, such as detailed plans and specifications, identified borrow sources, and environmental clearances. The HNC lock complex is one of the first work items. Preconstruction Engineering and Design on the lock was initiated in January 2000, and the lock is a critical component of both the Morganza to the Gulf risk reduction project and the authorized LCA project, Convey Atchafalaya River Water to Northern Terrebonne Marshes and Multipurpose Operation of Houma Navigation Lock (see section 10.1.7, LCA Program Uncertainties).

Given the size and complexity of the Morganza to the Gulf project, and the fact that not all borrow sources have been identified, most of the RPEIS is at a broad, programmatic level; however, the RPEIS includes a more in-depth analysis of features for which borrow sources have been identified and that could be constructed in the near future, including the HNC lock complex, the Bayou Grand Caillou floodgate, and levee reaches F and G-1. Borrow materials from construction of the lock would be used to construct adjacent levee reaches F and G-1. For these features, the RPEIS provides sufficient detail so that no further environmental clearances would be needed upon signing a Record of Decision. The remaining features would require supplemental NEPA documents before they could be constructed.

The non-Federal sponsor has requested that it be allowed to design and construct portions of the Morganza to the Gulf project as work-in-kind. The non-Federal sponsor would focus their effort on earthen levee construction (multiple lifts) concentrated between Reach E-2 and Reach L. The non-Federal sponsor would also construct floodgates on some typical bayous within the same geographical area, such as Bush Canal, Placid Canal, Bayou Pointe aux Chenes, Bayou Terrebonne, Humble Canal and Bayou Petit Caillou. Details regarding specific features and schedules for work-in-kind will continue to be coordinated between the USACE and the non-Federal sponsor throughout the design and construction phase of the project.

Following approval of the Chief of Engineers Report, the non-Federal sponsor and the Assistant Secretary of the Army (Civil Works) would need to enter into a MOU for work provided or performed prior to execution of a PPA. Execution of this MOU would allow the non-Federal sponsor to design and construct specified portions of the project in advance of construction authorization and be eligible to receive work-in-kind credit for their allowable expenses which are determined integral to the project as part of its cash contribution and are incurred after the date of signing the MOU. These work-in-kind credits are subject to entry into the MOU covering the work prior to its performance, authorization of the project, determination by the Assistant Secretary of the Army (Civil Works) that the work is integral to the project, and execution of a PPA.

The non-Federal sponsor understands that any design and construction work pursued that is integral to the TSP will not be eligible for credit unless Congress authorizes and appropriates funds for the project and a PPA is executed. Once construction funds are appropriated for this project, the non-Federal sponsor and the Department of the Army will enter into a PPA. After the signing of the PPA, the non-Federal sponsor can begin to acquire the necessary land, easements and rights of way to construct the project. Since project features cannot be advertised for construction until the appropriate real estate interests have been acquired, obtaining the necessary real estate in a timely fashion is critical to achieving the project schedule. At the completion of construction, project features would be turned over to the non-Federal sponsor, which would then be fully responsible for their OMRR&R.

9 Review of the PAC Report and RPEIS

In compliance with USACE policies and NEPA, input on projects is solicited from technical reviewers, other government agencies, and the public. The following sections briefly describe coordination and review of the Morganza to the Gulf PAC report and RPEIS.

9.1 Types of Reviews

The August 2011 Review Plan (USACE, 8/2011) consists of three major technical review components. The first component, District Quality Control, assures accountability for the technical quality of the PAC report. District Quality Control incorporates a team of reviewers similar in experience and structure to the project team, but who have not worked on the project prior to the review.

The second component, Agency Technical Review, is similar in structure to District Quality Control, but is performed outside of the New Orleans District by other USACE districts in coordination with the Mississippi Valley Division and the National Planning Center of Expertise for Coastal Storm Damage Reduction. The Agency Technical Review team includes about 15 reviewers from various technical fields.

Finally, an Independent External Peer Review (IEPR) Panel acts as a completely outside evaluation of the economic, engineering, and environmental analysis performed for the study, including the panel's assessment of the adequacy and acceptability of the economic, engineering, and environmental methods, models, and analyses used. The IEPR panel began reviewing the preliminary draft PAC report in June 2012 and will provide their final comments following public review.

In addition to the technical reviews described above, the report must undergo USACE legal and policy review. Legal review of the draft document is conducted prior to public review. Policy reviews are ongoing and will continue during public review of the draft PAC report and NEPA document. Once all required reviews are complete, the report will ultimately be reviewed by the Assistant Secretary of the Army (Civil Works) and coordinated with the Office of Management and Budget as appropriate for submission to Congress.

9.2 Value Engineering

In accordance with ER 11-1-321, the appropriate Value Engineering action has been completed for the PAC phase of this project. The Value Engineering study conducted in November 2010 (SVS, 2010) is valid for up to 6 years and must be re-addressed as appropriate beyond that period. All proposals indicating savings greater than $1 Million impacting plan formulation have been addressed in a document indicating whether the Value Engineering recommendation has been accepted and resolved, rejected, or will be evaluated at a later time, e.g. during final design. A number of recommendations should be deferred to design, and additional Value Engineering workshops will be completed on detailed designs. At least two Value Engineering workshops will be needed—one for levees and one for structures, but given the complexity of the HNC lock complex, it is estimated that a total of five workshops will be needed at a cost of $90,000 for each workshop or an estimated $450,000 for Value Engineering on the total project.

9.3 Planning Model Certification

EC 1105-2-412, Assuring Quality of Planning Models, requires certification of planning models used in USACE studies. Planning models are models and analytical tools that planners use to define water resources management problems and opportunities, to formulate potential alternatives to address the problems and take advantage of the opportunities, to evaluate potential effects of alternatives, and to support decision-making. EC 1105-2-412 does not cover engineering models used in planning, which are certified under a separate process. A summary and status of model certification for the PAC are shown in table 9-1.

Table 9-1. Planning Model Certification Status

Name	Purpose	Status of Certification
HEC-FDA Version 1.2.5a	Calculate flood damages and benefits for structures, contents and vehicles and part of emergency cost damages and benefits.	Certified
@Risk	Calculate water supply benefits and part of emergency cost damages and benefits.	Commercial off-the-shelf model to be approved for use.
RECONS	Capture the impacts to income, output, and employment for the regional economy that are associated with construction spending on each of the alternatives.	Certified
Wetland Value Assessment Models - Coastal Marsh Module Version 1.0	Evaluate coastal marsh impacts and benefits for the project alternatives and mitigation.	Approved on 28 February 2012*
Wetland Value Assessment Bottomland Hardwood and Swamp Models	Evaluate swamp and bottomland hardwood impacts and benefits for the project alternatives and mitigation.	Approved on 8 November 2011*

*WVA approval memos are included in Appendix F of the RPEIS.

9.4 Non-Federal Sponsor and Agency Review

The CPRAB and TLCD have expressed their support for the project and their intent to act as the non-Federal sponsors. Close coordination with the CPRAB and the TLCD has been maintained throughout the planning process.

The RPEIS has generated significant interagency interest up to this point with the full involvement of the Louisiana CPRA, CPRAB, DOTD, TLCD, SLLD, and the Morganza Habitat Evaluation Team. The Morganza Habitat Evaluation Team consists of representatives from USEPA, USFWS, NMFS, and other Federal and state agencies. Other outside agencies or NGOs could become involved during public review of the RPEIS and PAC report. USFWS concerns and recommendations are documented in the USFWS Coordination Act Report, which is part of the RPEIS.

There have been many public meetings on this project over the last few decades, and it has received widespread support from the community. Although the opinions of the landowners who will be directly affected by its construction are not known, the non-Federal sponsor is confident that landowner support will be high, and they will be able to acquire the lands, easements, and rights-of-way required for the project.

9.5 Public Review

This project continues to undergo extensive public review and comment. Since the start of the feasibility study in the mid-1990s, there has been an ongoing public outreach program to the Terrebonne and Lafourche Parish communities through public meetings, media day events, briefings to Parish Council Board Meetings, and other public presentations and discussions. Critical members of the Morganza to the Gulf team consist of the representatives from the State of Louisiana and local communities and they are involved in the key decisions discussed and developed by the team.

The USACE New Orleans District held a scoping meeting for a proposed hurricane and storm damage reduction system on May 12, 1993, in Houma, Louisiana and written comments were accepted from April 7 to May 24, 1993. Eleven letters were provided to the USACE and 52 individuals attended the scoping meeting. A scoping document that summarized comments and concerns was sent to all interested participants on April 12, 1994. The issues and concerns identified were considered during the planning and analysis of project alternatives.

The greatest area of public concern was related to the importance of providing hurricane, storm, and flood risk reduction for businesses and residences. Other concerns included potential adverse impacts to existing marshes, improvement of marsh habitat both inside and outside the proposed levee system, maintaining or improving ingress and egress of marine organisms for the benefit of commercial fisheries, and avoiding adverse water quality impacts.

The post-authorization report/plan has not yet undergone public review. USACE will continue to coordinate with the communities and the public and will hold additional public meetings. Formal review periods include the public review of the Draft documents (expected January/February2013) and Final NEPA review (expected May/June 2013). After public review of the PAC report/RPEIS, this section will summarize the public comments and discuss the impact of these activities on the recommendations.

10 Conclusions

The plan to provide hurricane and storm damage reduction to portions of Terrebonne and Lafourche Parishes in south Louisiana as updated in this PAC report is based on a thorough analysis and evaluation of all practicable alternatives, in view of applicable economic, engineering, and environmental criteria. Based on the data analyzed, the 1% AEP alternative has the greatest excess benefits over costs and is the TSP.

10.1 Planning Assumptions and Uncertainties

Given the complexity of this type of water resources project, analysts and decision makers do not have access to perfect information. Making simplifying assumptions in the face of large uncertainties is part of the normal planning process; however, decision makers need to be aware that conditions may change and planning assumptions could become invalid over time.

Key sources of risk and uncertainty are described in this section. Some types of risk and uncertainty can never be fully eliminated; however, measures or actions can be taken to reduce some risk and uncertainty, such as taking additional soil borings during detailed engineering design, monitoring sea level rise and subsidence to ensure the project continues to perform as designed into the future, monitoring and adaptively managing wetland mitigation projects, developing and rehearsing emergency operation and evacuation plans, and educating the public on residual risks of the levee system.

10.1.1 Non-Federal Levees

The without-project condition accounts for the existence of non-Federal levees within the Morganza project area (approximately 92 miles total; not all contiguous). Their performance was modeled using fragility curves. Most of the local levees are located close to development and are only intended to prevent tidal flooding from small tropical storm events, so they provide some benefit for the more frequent, lower flooding events, but tend to perform poorly at the 3% and 1% AEP surge events for which the Federal hurricane and storm damage risk reduction alternatives were formulated.

In the with-project condition, the performance of the local levees is not quantified. Once the Federal levee is in place, local levees are no longer subjected to direct hurricane surge. If a hurricane event is large enough to cause a breach in the project levees, then it is assumed the local levees would breach as well; therefore, the impact of not including the local levees in the analysis is minor.

Approximately 9 of the 92 miles of local levees are located along the Morganza to the Gulf PAC alignment. The non-Federal sponsor designed and constructed those 9 miles of levees with the intent of meeting HSDRRS standards so that the levees could eventually be incorporated into the Morganza Federal levee project. Per USACE policy, all local levees built without a signed PPA are part of the without-project conditions. Based on preliminary review of non-Federal levee designs, the assumption was made for the PAC report that the 9 miles of local levees would meet HSDRRS criteria and could be incorporated as a foundation to the Federal levees in those reaches. The approval process to incorporate the non-Federal levees into the Federal project would require detailed evaluation of plans and specifications and additional soil borings. Since that detailed review has not yet occurred, final determination of their suitability for integration into the Federal project cannot be made at this time. If the non-Federal levees are found to be incompatible with the Federal project, the Morganza PAC total project cost estimate may increase based on additional costs to degrade and rebuild the non-Federal levees, or to realign the

Federal project. Even if incorporated into the Federal project, the non-Federal sponsor would not receive credit for the cost of construction of the local levees (absent legislative lookback credit), but would be eligible to receive a credit for any LERs provided in response to USACE right-of-entry request in support of Federal construction efforts.

10.1.2 Economic Risk Analysis

Benefits modeled in HEC-FDA are expected to sufficiently replicate economic benefits of the alternatives. The risk-based analysis meets the intent of EC 1105-2-101 because all key variables, parameters, and components of the hurricane and storm damage reduction study have been subjected to probabilistic analysis. The key variables include stage-damage functions; stage- probability functions; length of record used to determine stage-probability confidence bands; and structural/geotechnical performance of levees.

Rainfall is not included in the HEC-FDA model because the Federal levee would not reduce rainfall damages. The UNET Model was used to evaluate rainfall and interior drainage on the protected side of the proposed hurricane levee system. Given the large storage areas behind the Federal levee (e.g. Lake Boudreaux), and environmental control structures throughout the levee alignment, additional pumping capacity for rainfall is not needed. Rainfall was also considered in sizing structures.

The without-project HEC-FDA model includes fragility curves that describe the reliability of the local levees. These fragility curves were developed using limited available data, stability analyses, and erosion evaluation. Wave overtopping was not considered; if the local levee does not fail, no damages are computed by the HEC-FDA model, even though wave overtopping could result in without-project damages. These assumptions resulted in overstating the performance of the local levee system and thus reduced the without-project damages that were used to compute project benefits.

The economic analysis performed for the with-project conditions represent the Federal levee performance by a single point fragility curve that has a zero percent probability of failure until a wave overtopping rate of 2 cfs/ft is reached, at which time, failure is considered likely. For all events where the wave overtopping is less than 2 cfs/ft, no damages are computed by the HEC-FDA model. The failure point chosen on the Federal levee would overstate residual damages and therefore understate benefits.

Recent full scale wave overtopping simulation research at Colorado State University (CSU) and simulation research projects on levees were performed to determine the need for armoring. This specific analysis forms the basis for the assumed performance of the proposed Federal grass-covered earthen levees. The upper estimate in the CSU tests was 2.0 cfs/ft. Levees could fail if armoring is not present and overtopping is greater than 2.0 cfs/ft. With the likelihood more certain, the failure probability for 2.0 cfs/ft was set at 95 percent.

A sensitivity analysis was performed on an economic reach for the with-project Federal levee with three test cases. Test Case A has a typical fragility curve developed from geotechnical and hydraulic analyses, Test Case B is the single point failure with the 100 percent probability at a surge elevation that results in 2 cfs/ft wave overtopping, and Test Case C is a single point failure with the 100 percent probability surge elevation at the top of levee. The sensitivity analysis demonstrated that the single point failure is a proxy for a typical fragility curve that meets the intent of the ER 1105-2-101 to address risk and obtain economic consequences. The with-project economic analysis using a single point fragility curve with a failure point at 2 cfs/ft wave overtopping understates the performance of the levee, calculating higher residual damages and therefore understating the benefit-cost ratio.

In the HEC-FDA model, once the wave overtopping reaches 2 cfs/ft, the Federal levees fail and interior stage becomes the without-project stage and residual damages are computed. A breach analysis for the with-project Federal levee demonstrated the interior stage with a breach is likely to be lower than the exterior stage and the without-project stage; the interior/exterior relationships used in the Federal levee analysis therefore understates the performance of the levee again understating the benefit-cost ratio.

In reviewing each of these assumptions, the USACE Risk Management Center concluded that the methodology used in this study resulted in underestimating the without-project damages. The analysis performed on the with-project conditions understated the performance of the Federal levees as well as overstated the residual damages due to the interior/exterior relationships used in the economic model.

10.1.3 Sea Level Rise and Subsidence (Relative Sea Level Rise)

There is widespread consensus in the international scientific community that sea levels will continue to rise and could accelerate. Coastal Louisiana's low elevation, high rate of subsidence, and increased rate of wetland loss make it vulnerable to changes in climate. Sea level change is defined and evaluated in terms of "relative sea level rise," which includes the effects of global and local sea level change as well as local subsidence. Although subsidence and sea level rise are independent processes, the net effect of the two processes results in local relative sea level rise, which is what matters for planning.

Unlike the 2002 report, the PAC structure inventory was not lowered to account for subsidence; rather, the surge and wave model accounts for both sea level rise and subsidence. Project designs in the PAC are based on the Intermediate RSLR scenario, which equates to increased water levels of 0.7 ft in the PAC base year (2035) and 2.4 ft in the PAC future year (2085). In the 2002 feasibility report analysis, to account for future sea level rise and subsidence, portions of the structure inventory fronted by healthy marsh were lowered by approximately 0.5 ft in the base year (2008) and 2.3 ft in the future year (2057). Portions of the structure inventory fronted by unhealthy marsh were lowered by approximately 0.7 ft in the base year and 3.1 ft in the future year. Note: The 2002 feasibility report evaluated a different 50-year period of analysis than the PAC report.

Based on storm surge and wave modeling for this study, the impact of sea level change on surge and waves is non-linear. Surge propagation over broad, shallow, wetland areas is highly sensitive to sea level rise. As wetlands deteriorate, it is likely that water depths will increase further and sea level rise will impact surge levels to an even greater extent, compared to the base case estimates. Waves also generally increased significantly for all sea level rise cases. The wave height increases are significant, but less dramatic than the surge increases.

10.1.4 Geotechnical Considerations for Multi-Lift Levee Construction

Multiple lifts are necessary to achieve and maintain levee design elevations over the 50-yr period of analysis. Levee designs represent the size/configuration required to attain the specified level of risk reduction (1% or 3% AEP) by the base year (2035) and the end of the analysis period (2085) accounting for settlement and the Intermediate RSLR scenario. Given the long construction period for this project, the final levee lifts could be adjusted to account for higher or lower levels of actual RSLR.

Constructing multiple levee lifts in a coastal environment with unstable sediments can present challenges. The project area contains large amounts of open water and many bayous, which results in heterogeneous soil foundations. As a result, parts of levees built on existing ridges or levees are expected to have much less settlement than connecting features. The USACE has a long history of working in the weak, compressible soils of southeast Louisiana and has incorporated this knowledge into the PAC feasibility-level levee and structure designs. About one-third of the subsurface exploration required for construction of the project has been completed. Data from each soil boring had to be extrapolated over a large area, which can result in inexact assumptions; however, efforts were made to provide a conservative, yet realistic design, that does not underestimate or overestimate costs because of limited data, or place significantly more emphasis on data that was retrieved from the bored locations. These designs are the basis for a representative PAC cost estimate, but are not intended to be the final engineering designs. Additional geotechnical exploration and testing is planned during the detailed design phase (plans and specs).

10.1.5 Levee Armoring

The selected method for increasing resilience of the Morganza to the Gulf levees in the case of wave overtopping is grass. The with-project economic analysis included the reliability of the constructed project with HSDRRS standards for grass and no additional armoring. Armoring with more resilient material, such as high performance turf reinforcement, involves a cost and performance tradeoff analysis between levee elevation (and associated overtopping rates) and armoring. For example, where sufficient overtopping storage exists behind the levee, levee elevations could be lowered if more robust armoring, e.g. concrete mats, were used to prevent erosion in the case of overtopping. For the Morganza PAC, a test case was run on one such levee reach to determine whether or not it would be more cost effective to add armoring and reduce the height of the levee. The preliminary results did not show a cost savings. The determination of whether or not additional armoring is necessary or cost effective should be made on a reach-by-reach basis; therefore, additional analysis on armoring should be conducted during PED.

10.1.6 Indirect Impacts

Creation of impounded wetlands with induced development and indirect impacts (flooding/freshwater into wetlands) has been and continues to be a controversial issue within the environmental community of Southern Louisiana. Maintaining ecosystem hydrology with drainage structures within the levee could be challenging in the future given some sea level rise scenarios. The issue is further exacerbated by the continued subsidence of the marsh lands; however, the wetland ecosystem will be impacted by relative sea level rise either with or without the Morganza project in place.

10.1.7 LCA Program Uncertainties

Several LCA projects authorized by WRDA 2007 are located within the Morganza study area, including but not limited to: (1) Convey Atchafalaya River Water to Northern Terrebonne Marshes and Multipurpose Operation of Houma Navigation Lock (2) Modification of Davis Pond Diversion and (3) Land Bridge between Caillou Lake and Gulf of Mexico. By letters dated 20 August 2012 and 16 October 2012, CPRAB has notified the Corps that it desires to suspend study and design on these projects. The decision of CPRAB to suspend these projects results in some degree of uncertainty regarding implementation of these projects as part of the authorized Federal LCA.

The only LCA project with a direct link to a feature of the Morganza project is the Convey Atchafalaya River Water to Northern Terrebonne Marshes and Multipurpose Operation of Houma Navigation Lock project. The HNC lock complex to be constructed as part of the

Morganza to the Gulf project for storm surge and salinity control could also be operated for ecosystem restoration purposes, such as distribution of freshwater. Proposed operational changes for LCA ecosystem restoration purposes, and associated impacts, are documented in the *Final Integrated Feasibility Study and Environmental Impact Statement for the Convey Atchafalaya River Water to Northern Terrebonne Marshes and Multipurpose Operation of Houma Navigation Lock* (USACE, 2010). The LCA plan relies on the operation of the HNC lock for environmental purposes after 2025 and proposes the modification of the operational plan for the lock complex structure authorized under Morganza to the Gulf, in order to maximize potential environmental benefits, both in terms of avoiding saltwater intrusion and optimizing flow distribution. For the multipurpose operation to occur, the LCA project would need an OMRR&R plan that considers operation of the lock beyond the current authorization of the Morganza to the Gulf project. A detailed multipurpose OMRR&R plan including these environmental purposes has not yet been developed.

10.1.8 Sponsor Funded Additional Work Item to Address Future HNC Depth

Considering the uncertainties associated with potential future deepening of the HNC, the benefits of building a more adaptable lock complex are significant for the Nation. The non-Federal sponsor would assume all incremental costs and incremental OMRR&R of the sponsor funded additional work item. The overall benefits of implementing the sponsor funded additional work item outweigh the additional costs that result from the deeper sill depth. Thus, the New Orleans District has included the -23 ft NAVD88 sill elevation as part of the TSP as a sponsor funded additional work item. Significant coordination with the resource agencies has been undertaken on both the 1% AEP alternative and the sponsor funded additional work item. No issues have been raised at this stage in the planning process that would preclude implementation of either project.

10.1.9 Price Levels and Interest Rates for Economic Evaluations

Price levels and interest rates change over time and impact the economic viability of projects. Benefits and costs for the economic analysis of the *initial array* of alternatives are in October 2008 price levels and based on a 4.875 percent interest rate. Benefits and costs for the economic analysis of the *final array* alternatives are in October 2011 price levels and based on a 3.75 percent interest rate. The long-term implementation approach carries with it significant risks for Federal and local funding shortfalls. The long implementation time also increases the probability that the levees could be damaged by storms before they are completed.

10.2 Residual Risk

No alternative plan can eliminate risk and uncertainty, and tradeoffs must be made among engineering performance, economic performance, and project costs. These benefit and cost tradeoffs are often expressed as local and Federal project costs, flood damage reduced, and residual risk. It is vital that the non-Federal sponsor and residents understand these tradeoffs in order to fully participate in an informed decision-making process.

10.2.1 Compliance with Executive Order 11988 and Policy Guidance Letter 25

Executive Order 11988, 24 May 1977, Floodplain Management outlines the responsibilities of Federal agencies in the role of floodplain management such that each agency shall evaluate the potential effects of actions on floodplains and should not undertake actions that directly or indirectly induce growth in the floodplain, unless there is no practical alternative. USACE Policy Guidance Letter 25 further specifies that structural plans will be formulated to protect "existing development and vacant property that is interspersed with existing development… and for vacant property that is not interspersed with existing development if it can be demonstrated that the vacant property would be developed without the project and benefits are based on savings in future flood proofing costs or reduction in damages to future development."

The growth in population and housing that has been observed within the study area in past decades, as documented in U.S. Census data, is expected to continue under without-project conditions. These projections of population and housing growth were based upon the results of a macroeconomic analysis conducted by Moody's Economy.com that links population growth (and associated demand for housing and commercial services) to an underlying growth in employment demand in the region. Details are provided in the Economic Appendix to this report. A primary conclusion for this study is that the implementation of either structural alternative will not result in a change in the level of employment within the study area since any storm surge risk reduction system will not promote further growth within the major employment sectors comprised of oil and gas exploration and development, commercial fishing, and agriculture. Rather, the structural plans are expected to preserve economic activities that exist, or would be expected to exist in the future, under without-project conditions. Since no induced economic development, and associated population and housing growth, is expected as a result of project implementation, the recommendations of this report are consistent with the above-referenced executive order and policy guidance letter.

In the advent of project implementation, a closer review of the implications for residual risk for the inventory of residential and commercial structures expected to be placed in service after the base year is warranted. Under without-project conditions, building ordinances, reflecting the floodplain regulations mandated by participation in the National Flood Insurance Program, require that new residential or commercial structures be constructed with first-floor elevations placed one foot above the base flood elevation (BFE) as indicated in the prevailing flood rate insurance maps (FIRMs), published by FEMA. As FEMA periodically updates its flood rate insurance studies and associated FIRMs, the BFEs are expected to change over time. The economic analysis in this report was conducted consistent with this expectation as the lower portion of the first-floor level of future (without-project) structures are added to the structure inventory at elevations that are at or above the stage associated with the 1% ACE (equivalent to the BFE). In this way, structures placed into service in the future are compliant with flood plain regulations. Also, these structures are expected to be subject to flood risk for events less probable than the 1% ACE.

Under with-project conditions, the FEMA-established BFEs in future updates of the FIRMs are not expected to be as high as would have been established under without-project conditions, owing to the performance of the structural plans in place. The potential damage to these residential or commercial structures is expected to be higher for storm surge events that exceed the performance of the structural alternative in place. This conclusion is based upon the observation that the BFE under without-project conditions is likely to be higher than under with-project conditions. Also, under the without-project condition, structures subject to repetitive loss were elevated in future analysis years, while structures behind the proposed levee project in the with-project condition were not. As a result, residual risk is higher under with-project conditions relative to without-project conditions should the Federal levee not perform as intended.

10.2.2 Measures to Reduce Loss of Life and Damages to Property

Local authorities have and are continuing to develop procedures and ordnances to reduce the area's risk from storm events. Currently, the State of Louisiana has an evacuation plan for the study area. Depending on the severity of the storm event, these evacuations will be either voluntary or mandatory.

As population is expected to grow under future without-project conditions, the population at risk to flooding is also expected to increase. Insofar as the structural plans do not induce development of population and housing, there is no further change in the number of persons exposed to residual risk than would have existed under without-project conditions. Yet, in cases where the surge events exceed the design of the structural projects, the additional population that is counted within the study area beyond the base year will be exposed to increased flood hazard.

All coastal parishes, Terrebonne and Lafourche in particular, exercise aggressive evacuation plans which are mandatory by state law and coordinated by the State of Louisiana according to the state’s emergency operations plan that is put into effect 72 hours prior to expected landfall of tropical storms. The effectiveness of evacuation response of the affected population (generally in the 80 to 95 percent range) is not expected to change irrespective of project implementation. The conclusion is that an increase in population in the study area in the future corresponds to an increase in the number of individuals that may remain in the study area after an evacuation order is issued, and thus an increase in the number of individuals exposed to residual risk associated with storm surges that exceed the project design. This means that for the approximately 8,900 persons added to the population between the years 2035 (the base year of the project) and 2085, most of whom would evacuate in advance of an approaching storm, an additional 445 to 1,780 persons would face life-loss risks in the event of project exceedance. Under such conditions, the parishes’ emergency recovery plans would become operational to facilitate cleanup and repair of public facilities, to ensure public safety as population returns to the area in managed phases, and to coordinate relief services with state and federal officials. While the requirement to respond to the needs of additional population under such catastrophic conditions places additional burden on parish law enforcement, relief personnel and facilities, and financial resources, the plans themselves are not expected to be altered to accommodate the change in scope of emergency operations.

In addition to evacuation measures to protect life, local officials are continuing develop measures to reduce the risk of damage to properties from storm surges. The National Flood Insurance Program enables property owners to purchase insurance as a protection against flood losses in exchange for state and community floodplain management regulations that reduce future flood damages. Both Terrebonne and Lafourche Parish participate in the regional planning district, referred to as Louisiana Planning District Number 3. Under the planning rules for this district, new residential construction and substantial improvement of any residential structure must have the lowest floor elevated to or above the base flood elevation. This measure reduces the risk of damages to new developments in the future.

The 1% AEP standard is important within the National Flood Insurance Program because a levee certified to the 1% AEP (100-year) design level could reduce National Flood Insurance Program insurance premiums within the levee system. The TSP (1% AEP levee design) is intended to meet FEMA 100-year levee certification requirements. Project design and performance by levee reach would be verified during PED to assure compliance with FEMA certification criteria.

10.2.3 Narrative Future Scenario

Some risk and uncertainty factors associated with the Morganza to the Gulf project are difficult to quantify. The following future scenario for the year 2035 is included to help communicate risk.

By 2035, after two decades of additional wetland degradation and sea level rise, water levels in the Gulf of Mexico and waterways throughout the area may be almost a foot higher than they are today, resulting in even higher storm surges than have been seen in the past. Should Houma and surrounding communities in Terrebonne and Lafourche Parishes be threatened by a hurricane, over 181,000 individuals would be faced with the decision of when to begin voluntary evacuations. Approximately 50 hours before the onset of tropical storm winds, the State of Louisiana and local officials would begin mandatory evacuations.

If the Morganza to the Gulf hurricane levee system were never built, the 100-year surge event (which has a 1 percent chance of occurring each year) could overtop and breach most of the existing local levees resulting in over 18 ft of flooding in some areas and potentially impacting over 134,000 structures, including homes, businesses, boats, and automobiles that could not be evacuated. Because of the lack of natural drainage in some areas, flood water would likely remain in low-lying areas for 2 weeks or more, as seen in the aftermath of Hurricane Katrina.

Alternately, if a system of earthen levees ranging in elevations of 10.5 to 24 ft were in place in 2035, it is expected that the project would most likely be able to withstand a 1 percent chance event and structures within the levee system would remain undamaged by storm surge (structures would still be subject to wind damage). Even with the 1% AEP Plan, the project area could still flood in extremely rare events, but would have reduced risk of flooding up to the 500-year or 0.2 percent annual chance flood event.

10.3 Unresolved Issues

Given the size and complexity of the Morganza to the Gulf project, some issues could not be fully resolved at a feasibility-level of detail within the PAC timeframe. Issues that should be resolved at a greater level of detail as the project moves forward include the potential for induced flooding outside the levee system and the future level of risk reduction for the Larose to Golden Meadow project. These plan components would be further addressed through detailed design and supplemental NEPA documents.

10.3.1 Induced Flooding Outside the Project

Construction of the project has the potential to raise water levels immediately outside the levees by several feet during storm events. These areas include portions of the communities of Gibson, Bayou Du Large, Dulac, Cocodrie, and Isle de Jean Charles. Presently, information is not available on the specific details on the differences in frequency, depth, and duration of the flooding between the future without-project and future with-project conditions. This detailed information typically would be assessed in light of the uses to which the particular land is zoned, and the appropriate mitigation methods, if any, would be implemented to address the effects of the Federal project. Because of the vast scope of this project and the limited amount of available information at this time, the USACE did not look at each affected parcel individually in order to determine potential impacts to property rights from the proposed Federal action that may give rise to compensation. For example, without more information, it is impossible to rule out the possibility of takings for all of the structures in these communities. Due to this concern, the USACE for purposes of this report, has assumed the worst case compensation scenario (most expensive option), a 100 percent buy-out of all of the structures in the impacted areas. The cost and associated benefits with this scenario has been incorporated into the TSP (see section 6.5.1).

10.3.2 Larose to Golden Meadow Project Future Elevations

The future-without condition for the Larose to Golden Meadow levee system is uncertain since the Larose PAC analysis is ongoing and future levee elevations for the existing Larose ring levee system have not yet been determined. If the Morganza project is re-authorized to the 1% AEP level of risk reduction, but the Larose project is (a) not re-authorized; (b) re-authorized to less than a 2% AEP level of risk reduction; or (c) is authorized but not supported by a financially capable Non-Federal Sponsor willing to execute a PPA, the Morganza project would have added costs to both offset induced stages on the existing Larose system and to complete the Morganza system to ensure no overtopping of the Larose C-North levees that could impact the Morganza risk reduction area. Therefore, the Morganza to the Gulf PAC analysis assumes no further upgrades to the Larose to Golden Meadow system to ensure that all potential costs to complete the Morganza system are considered.

10.4 Cost and Schedule Risk

The cost and schedule risk analysis is intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as projects progress through planning and implementation. These conclusions were reached by identifying and assessing risk items for use in the risk analysis. The quantitative impacts of these risk items are then analyzed using a combination of professional judgment, empirical data, and analytical techniques. The total project cost contingency is computed using the Crystal Ball software.

10.4.1 Project Confidence and Cost Contingencies

Based on the cost and schedule risk analysis, the recommended total project contingency is approximately 35 percent for the structural features and 26 percent for the levees and all other features, based on an 80 percent confidence level. This contingency of almost $2.3 billion was applied to the estimate for the Morganza to the Gulf post-authorization TSP.

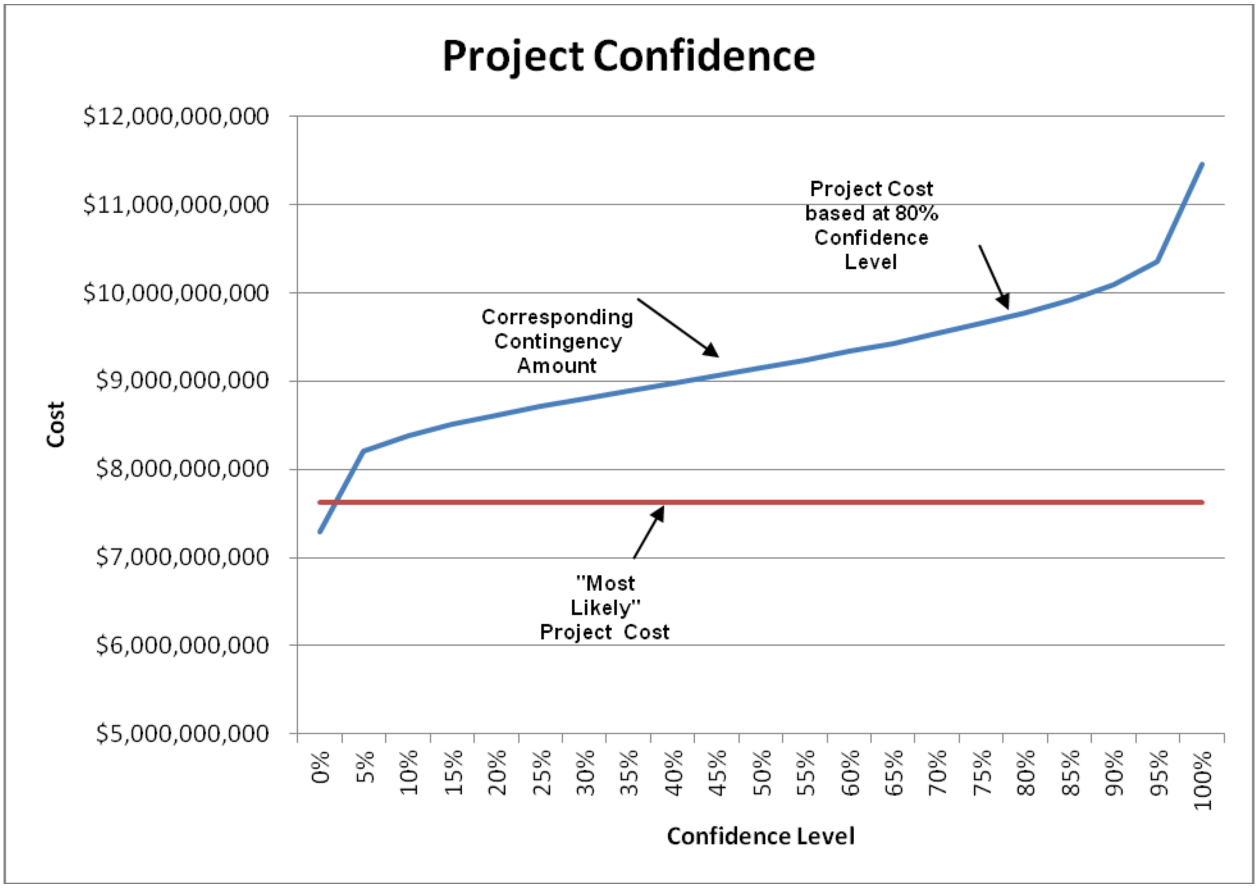

Figure 10-1. Graph of Project Cost vs. Confidence Level

Note: Real estate costs not included because real estate contingencies were computed separately.

10.4.2 High Risk Cost and Schedule Items

An important outcome of the cost and schedule risk analysis is the communication of high risk areas which have a high potential to affect the project cost and/or schedule. For the Morganza to the Gulf PAC project, the high risk cost items are the structural and geotechnical uncertainty, steel cost, fuel cost, unidentified borrow pit for hauled in material, and construction modifications. Some of these risk items can be mitigated, reducing the risk of an increased project cost. Mitigation measures for structural and geotechnical uncertainty cannot be determined until further studies and engineering data are obtained. The risk analysis already includes a conservative view of the trends for fuel and steel costs based on input from suppliers, research of the market and professional judgment. Construction modifications are very common and often inevitable on a project of this magnitude. No cost for modifications was included in the base cost estimate and the amount of additional cost due to modifications can be mitigated by ensuring QA/QC guidance is followed and quality products are advertised for construction.

Borrow pit locations for some levee reaches and future levee lifts are unknown at this time. The geology of southeast Louisiana is sufficiently known, however, to reasonability assume that sufficient clay borrow sources would exist within an average distance of 20 to 25 miles to project sites. Encouraging the non-Federal sponsor to find suitable borrow at closest possible distance can mitigate for this risk.

The highest risk schedule item is funding availability. The project schedule was developed based on a reasonable timeframe to establish a level of risk reduction for the area. The USACE has little to no control over the congressional appropriation process other than to fully and timely execute the monies provided in an attempt to show the urgency and importance of the project.

10.4.3 Potential Risk Assessment Impacts on Project Costs

This PAC report reflects the current estimated costs, which are the best available and compliant with current standards. The USACE is conducting a risk assessment to ensure risk is addressed consistently across the country. Once this assessment is complete, the results may be applied to the Morganza to Gulf project area. Risk-based modifications to current design criteria have the potential to reduce the total project cost estimates reflected in the PAC report. Such modifications would be made to designs and costs during the next phase of implementation, Pre-construction Engineering and Design (PED).

11 References

This section includes the list of references cited in the report, a glossary of terms, and list of acronyms. Many of the report documents are available online at www.mvn.usace.army.mil/prj/mtog/.

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11.2 Glossary

Alternative or Alternative Plan – A set of one of more management measures functioning together to address one or more objectives.

Annual Chance Exceedance (ACE) – A measure of the likelihood (expressed as a probability) of a flood event reaching or exceeding a particular magnitude. A one percent (ACE) flood event has a one percent (or 1 in 100) chance of occurring or being exceeded at a location in any year.

Annual Exceedance Probability (AEP) – The probability that flooding will occur in any given year considering the full range of possible annual floods (ER 1105-2-101), or the chance of an event of a given size (or larger) occurring in any one year, usually expressed as a percentage (EC 1110-2-6066).

Anthropogenic – Caused by human activity.

Assurance – The probability that a target stage will not be exceeded during the occurrence of a specified flood. Assurance is also interchangeable with the term **conditional non-exceedance probability** (EC 1110-2-6066).

Benefits – Valuation of positive performance measures.

Bottomland Hardwood Forest – Low-lying forested wetlands found along streams and rivers.

Brackish Marsh – Intertidal plant community typically found in the area of the estuary where salinity ranges between 4 and 15 ppt.

Coastal – Characterization of a structure or system that is situated in an environment subject to water level fluctuations and wave action. Coastal structures or systems must typically be designed to take into account storm surge and wave loadings (EC 1110-2-6066).

Conditional Non-exceedance Probability (CNP) – The probability that a target stage will not be exceeded during the occurrence of a specified flood. Conditional non-exceedance probability is also interchangeable with the term **assurance** (EC 1110-2-6066).

Control Structure – A gate, lock, or weir that controls the flow of water.

Cumulative Impacts – The combined effect of all direct and indirect impacts to a resource over time.

Datum – A point, line, or surface used as a reference, as in surveying, mapping, or geology.

Direct Impacts – Those effects that result from the initial construction of a measure. Contrast with "Indirect Impacts."

Economic – Of or relating to the production, development, and management of material wealth, as of a country, household, or business enterprise.

Economic Analysis Period – The period of time over which the flood risk management system would have significant beneficial or adverse effects. Usually this period does not exceed 50 years except for major multi purpose reservoir projects (EC 1110-2-6066).

Ecosystem – An organic community of plants and animals viewed within its physical environment (habitat); the ecosystem results from the interaction between soil, climate, vegetation and animal life.

Ecosystem Restoration – Activities that seek to return an organic community of plants and animals and their habitat to a previously existing or improved natural condition or function.

Endangered Species – Animals and plants that are threatened with extinction.

Environmental Impact Statement (EIS) – A document that describes the positive and negative environmental effects of a proposed action and the possible alternatives to that action. The EIS is used by the federal government and addresses social issues as well as environmental ones.

Estuary – A semi-enclosed body of water with freshwater input and a connection to the sea where fresh water and salt water mix.

Estuarine – Related to an estuary.

Feasibility Report – A description of a proposed action previously outlined in a general fashion in a Reconnaissance Report that will satisfy the Federal interest and address the problems and needs identified for an area. It must include an assessment of impacts to the environment (either in an Environmental Assessment, or the more robust Environmental Impact Statement), an analysis of alternative methods of completion, and the selection of a Recommended Plan through the use of a cost-effectiveness analysis.

Feature – A constructible increment of an alternative plan.

Final Array – The final grouping of alternative plans from which a final recommendation can be made.

Fresh Marsh – Intertidal herbaceous plant community typically found in that area of the estuary with salinity ranging from 0 to 3 ppt.

Goals – Statements on what to accomplish and/or what is needed to address a problem without specific detail.

Gradient – A slope; a series of progressively increasing or decreasing differences in a system or organism.

Habitat – The place where an organism lives; part of physical environment in which a plant or animal lives.

Habitat Loss – The disappearance of places where target groups of organisms live. In coastal areas, usually refers to the conversion of marsh or swamp to open water.

Hazardous, Toxic, and Radioactive Wastes (HTRW) – Projects features must be examined to ensure that their implementation will not result in excessive exposure to pollutants possibly located in the study area.

Herbaceous – A plant with no persistent woody stem above ground.

Hydraulics - The scientific study of water and other liquids, in particular their behavior under the influence of mechanical forces and their related uses in engineering (from The American Heritage® Science Dictionary.)

Hydrodynamics – The continuous change or movement of water.

Hydrology – The pattern of water movement on the earth's surface, in the soil and underlying rocks, and in the atmosphere.

Indirect Impacts – Those effects that are not as a direct result of project construction, but occur as secondary impacts due to changes in the environment brought about by the construction. Contrast with "Direct Impacts."

Infrastructure – The basic facilities, services, and installations needed for the functioning of a community or society, such as transportation and communications systems, water and power lines, and public institutions including schools, post offices, and prisons.

Intermediate Marsh – Intertidal herbaceous plant community typically found in that area of the estuary with salinity ranging from 2 to 5 ppt.

Intertidal – Alternately flooded and exposed by tides.

I-Wall – A slender cantilever wall, deeply embedded in the ground or in an embankment that rotates when loaded and is thereby stabilized by reactive lateral earth pressures (EC 1110-2-6066).

Levee – A linear mound of earth or concrete floodwall built to stop or slow down storm surge.

Levee System – A levee system comprises one or more levee segments which collectively provide flood damage reduction to a defined area. The levee system is inclusive of all features that are interconnected and necessary to ensure protection of the associated separable floodplain (EC 1110-2-6066).

Level-of-Protection – The recurrence interval of the flood event that, with a high level of assurance, will be safely contained within the capacity of the protection system (EC 1110-2-6066). For example, a system could be deemed a 100-year Level-of-Protection system if it can contain the 1 percent annual chance exceedance flood with a high degree of assurance, e.g. 90 percent.

Sponsor Funded Additional Work Item – Alternative feature preferred by non-Federal sponsor for which the non-Federal sponsor agrees to pay the full cost increment.

Management Measure (or Measure) – A feature (a structural element that requires construction or assembly on-site) or an activity (a nonstructural action) that can be implemented at a specific geographic site that is to address one or more planning objectives. Management measures are the building blocks of alternative plans (Planning Guidance Notebook, 2-4).

Methodology – A set of practices, procedures, and rules.

Modes of Failure – The mechanism by which a system or structure ceases to perform its intended function (EC 1110-2-6066).

National Environmental Policy Act (NEPA) – Ensures that Federal agencies consider the environmental impacts of their actions and decisions. NEPA requires all Federal agencies to consider the values of environmental preservation for all significant actions and prescribes procedural measures to ensure that those values are fully respected.

No Action Alternative – An alternative that describes the without-project condition if no action is taken.

Objectives – More specific statements than "Goals," describing how to achieve the desired targets.

Organic – Composed of or derived from living things.

Overtopping – A static and/or dynamic event that occurs when the height of the stillwater level and/or associated waves exceed the top of a structure or levee embankment.

Prime Farmland – Land that has the best combination of physical and chemical characteristics for producing food, feed, fiber, forage, oilseed, and other agricultural crops with minimum inputs of fuel, fertilizer, pesticides, and labor, and without intolerable soil erosion. One of the categories of concern in the EIS.

Probability – A measure of the likelihood, chance, or degree of belief that a particular outcome or consequence will occur. A probability provides a quantitative description of the likelihood of occurrence of a particular event. This is expressed as a value between 0 and 1 (EC 1110-2-6066).

Probability Function – A discharge-exceedance or stage-exceedance probability relationship for a reach developed by traditional, site-specific, hydrologic engineering analysis procedures (EC 1110-2-6066).

Programmatic Environmental Impact Statement (PEIS) – An Environmental Impact Statement that supports a broad authorization for action, contingent on more specific detailing of impacts from specific measures.

Project – A constructible increment of an alternative plan.

Quantitative – Able to assign a specific number; susceptible to measurement.

Reach – The term Reach is used to describe two distinct features in the PAC analysis. (1) Levee Reach refers to a segment of the proposed Morganza to the Gulf levee alignment that has similar levee elevations, ground surface elevations, soil types, and foundation strengths. The ten primary Levee Reaches are Barrier, A, B, E, F, G, H, I, J, K, and L. (2) Hydraulic and/or

Economic Reach refers to an area that has similar water surface elevations and is used to aggregate economic damages and benefits. The Morganza study area has been divided into 276 Hydraulic/Economic Reaches, which are also sometimes referred to as Storage Areas.

Reconnaissance Report – A document prepared as part of a major authorization that examines a problem or need and determines if sufficient methods and Federal interest exists to address the problem/need. If so, then a "Feasibility Report" is prepared, which details the solution and its impacts further.

Redundancy – The duplication of critical components of a system with the intention of increasing reliability of the system, usually in the case of a backup or fail-safe (EC 1110-2-6066).

Relative Sea Level Rise (RSLR) – The sum of the sinking of the land (subsidence) and eustatic sea level change; the change in average water level with respect to the surface.

Reliability – The probability of a component, unit or system adequately performing its intended purpose, for a specified period of time, under given operating conditions (EC 1110-2-6066).

Residual Risk – The flood risk that remains in the floodplain after a proposed flood risk reduction project is implemented. Residual risk includes the consequence of capacity exceedance as well as consideration of project performance.

Resilience – The ability to avoid, minimize, withstand, and recover from the effects of adversity, whether natural or manmade, under all circumstances of use (EC 1110-2-6066).

Risk – The probability an area will be flooded, resulting in undesirable consequences (ER 1105-2-101).

Risk Analysis – An approach to evaluation and decision making that explicitly, and to the extent practical, analytically, incorporates considerations of risk and uncertainty in a flood damage reduction study (ER 1105-2-101).

Robustness – The ability of a system to continue to operate correctly across a wide range of operational conditions (the wider the range of conditions, the more robust the system), with minimal damage, alteration or loss of functionality, and to fail gracefully outside of that range (EC 1110-2-6066).

Safety – Commonly thought of as the condition of being free from danger, risk, or injury; however, safety is not something that can be absolutely achieved or guaranteed. Instead safety is the condition to which risks are managed to tolerable levels. Therefore, safety is a subjective concept based upon individual perceptions of risks and their tolerability.

Saline Marsh – Intertidal herbaceous plant community typically found in that area of the estuary with salinity ranging from 12 to 32 ppt.

Salinity – The concentration of dissolved salts in a body of water, commonly expressed as parts per thousand (ppt). The salinity of ocean water is approximately 35 ppt.

Scoping – Soliciting and receiving public input to determine issues, resources, impacts, and alternatives to be addressed in the draft EIS.

Social – Relating to human society and its modes of organization.

Socioeconomic – Involving both social and economic factors.

Still Water Level or Elevation – The height of the water surface measured above a datum without waves.

Storm Surge – An abnormal and sudden rise of the sea along a shore as a result of the winds of a storm.

Structural Superiority – All new structures that are difficult to construct due to their nature, such as railroad and highway gate monoliths that require detours causing disruptions to traffic, pumping station fronting protection that require cofferdams within their discharge basins causing reductions to pumping capacity, sector gated structures causing disruptions to navigation, large utility crossings, etc., shall be designed with a minimum of 2 ft. of additional wall height.

Subsidence – The gradual downward settling or sinking of the Earth's surface with little or no horizontal motion.

Tainter Gate - Radial gate most commonly used on navigational projects. In its simplest form, a tainter gate is a segment of a cylinder mounted on radial arms that rotate on trunnions anchored to the piers. Because of its simple design, relatively light weight, and low hoist-capacity requirements, the tainter gate is considered one of the most economical and most suitable gates for controlled spillways.

T-wall – A cantilever T-type reinforced concrete floodwall consists of a concrete stem and base slab which form an inverted T. The structural members are fully reinforced to resist applied moments and shears. As necessary to resist under seepage during a flood event, a steel sheet pile cutoff wall is cast into the base slab of the T-Wall. The T-wall may need to be supported on a pile foundation if soft soils exist. The piles can be made of either steel or concrete and derive their support to the T-wall from friction of the soil surrounding the pile or through end bearing at a deeper stronger soil strata.

Uncertainty – A measure of imprecision of knowledge of parameters and functions used to describe the hydraulic, hydrologic, geotechnical, and economic aspects of a project plan (ER 1105-2-101).

Unique Farmland – Land other than Prime Farmland (see "Prime Farmland") that is used for the production of specific high-value food and fiber crops, such as citrus, tree nuts, olives, cranberries, fruits, and vegetables.

Upland – A general term for non-wetland elevated land above low areas along streams or between hills.

Water Resources Development Act (WRDA) – A bill passed by Congress that provides authorization and/or appropriation for projects related to the conservation and development of water and related resources.

11.3 Measurement Abbreviations

cfs	cubic feet per second
cfs/ft	cubic feet per second per linear foot
ft	foot or feet
ppm	parts per million
ppt	parts per thousand

11.4 Acronyms

Acronyms used in the RPEIS are not listed here because the RPEIS has its own list of acronyms.

ACE	Annual Chance Exceedance
AEP	Annual Exceedance Probability
BFE	Base Flood Elevation
BLH	Bottomland Hardwood
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CPRA	Coastal Protection and Restoration Authority (formerly the Office of Coastal Protection and Restoration)
CPRAB	Coastal Protection and Restoration Authority Board (formerly the CPRA)
CSVR	Content-to-Structure Value Ratio (see Economic Appendix)
CWPPRA	Coastal Wetlands Planning, Protection, and Restoration Act
DNR	Department of Natural Resources
DOTD	Department of Transportation and Development
EC	Engineering Circular
EIS	Environmental Impact Statement
ER	Engineering Regulation
FEMA	Federal Emergency Management Agency (see Economic Appendix)
FIRM	Flood Insurance Rate Map
GIS	Geographic Information System
GIWW	Gulf Intracoastal Waterway
HEC-FDA	Hydrologic Engineering Center - Flood Damage Analysis
HNC	Houma Navigation Canal
HSDRRS	Hurricane and Storm Damage Risk Reduction System
LACPR	Louisiana Coastal Protection and Restoration
LCA	Louisiana Coastal Area
LERRD	Lands, Easements, Rights-Of-Way, Relocation, and Disposal Areas
LiDAR	Light Detection and Ranging
MLODS	Multiple Lines of Defense Strategy
MOU	Memorandum of Understanding
NAVD	North American Vertical Datum
NEPA	National Environmental Policy Act
NGO	Non-Governmental Organization

NGVD	National Geodetic Vertical Datum
NMFS	National Marine Fisheries Service
OMRR&R	Operation and Maintenance, Repair, Replacement and Rehabilitation
OSE	Other Social Effects (see Economic Appendix)
PAC	Post Authorization Change
PED	Preconstruction Engineering and Design
PEIS	Programmatic Environmental Impact Statement
PL	Public Law
PPA	Project Partnership Agreement
RED	Regional Economic Development (see Economic Appendix)
RPEIS	Revised Programmatic Environmental Impact Statement
RSLR	Relative Sea Level Rise
SLLD	South Lafourche Levee District
TLCD	Terrebonne Levee Conservation District
TSP	Tentatively Selected Plan
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
WMA	Wildlife Management Area
WRDA	Water Resources Development Act
WVA	Wetland Value Assessment